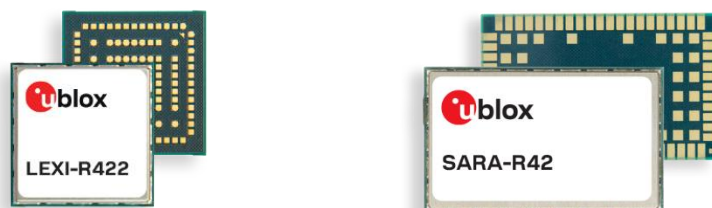# LEXI-R422 / SARA-R42

Application development guide

Application note

Abstract

This document provides detailed technology architecture and examples of how to use AT commands with u-blox SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422 modules.

Document information

Title	**LEXI-R422 / SARA-R42**	
Subtitle	Application development guide	
Document type	Application note	
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Disclosure restriction	C1-Public	

This document applies to the following products:

Product name
SARA-R42 series
LEXI-R422

Contents

1 Getting Started

This document provides guide for developing applications with the u-blox SARA-R42 series and LEXI-R422 modules, including AT command sequences examples.

Figure 1 shows the supporting documentation through the product design lifecycle. Table 1 shows a summary of the documentation available for SARA-R42 and LEXI-R422 modules.
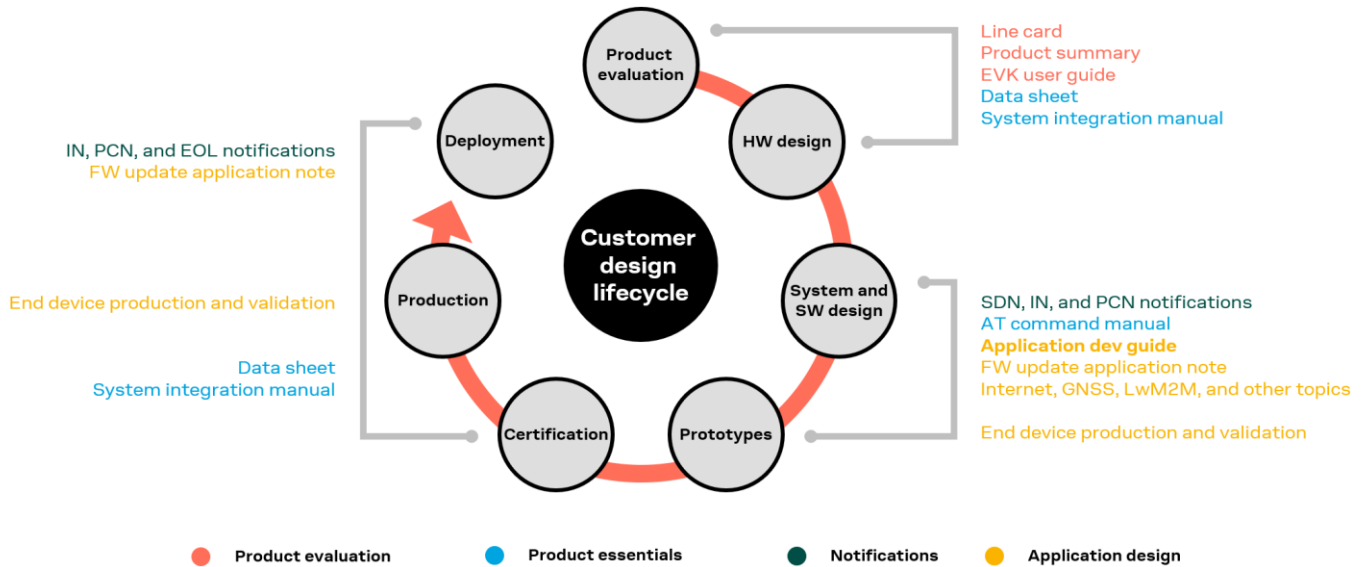
Figure 1: u-blox product documentation map

Document scope	Document name	Notes
Product evaluation	EVK user guide [14] [15]	SARA-R42 / LEXI-R422 evaluation kit guide.
Product essentials	Data sheet [2] [3]	Performance and characteristics of a product (family)
	System integration manual [5]	Describes how to design a product (family) into a customer application
	AT commands manual [1]	Reference guide for protocols, detailed AT command descriptions.
Notifications	Sample Delivery Note / Information Note / Product Change Note / End of Life	Notifications of SW / HW / Certification changes.
Application design	Application development guide	This document. **Start here!**
	FW update app note [6]	FW update procedures (EasyFlash, FOAT, FOTA, and uFOTA).
	Internet applications development guide app note [9]	Any applications relying on the IP stack (sockets, MQTT, MQTT-SN, HTTP, FTP, CoAP, SSL/TLS).
	production and validation test app note [7] [8]	Guidelines of OEM production test and validation test. Contact tech support for this document.
	Positioning implementation app note [10]	GNSS interface and aiding clients. Techniques for hybrid positioning and timing indication.
	LwM2M application note [12]	Details about the LwM2M options to achieve a few mandatory objects, extensible object and Firmware Over The Air update (uFOTA).
	AT command connect to AWS IoT core [13]	Examples of how to use AT commands to interact with the AWS IoT service.
	Mux implementation app note [11]	Usage of multiplexer with cellular modules.
Tools	m-center AT scripts collection	https://github.com/u-blox/m-center

Table 1: SARA-R42 / LEXI-R422 documentation overview

The following symbols highlight important information:

☞ An index finger points out key information pertaining to module integration and performance.

⚠ A warning symbol indicates actions that could negatively impact or damage the module.

2 Application design and development

When designing a host application interfacing with a u-blox cellular module, consider the points depicted in Figure 2:

- Choose the module's features that the application needs, and the ones that can be disabled.
- Split the application workflow to stages.
- Design the application to work in several modes, reflecting the lifecycle of the product.
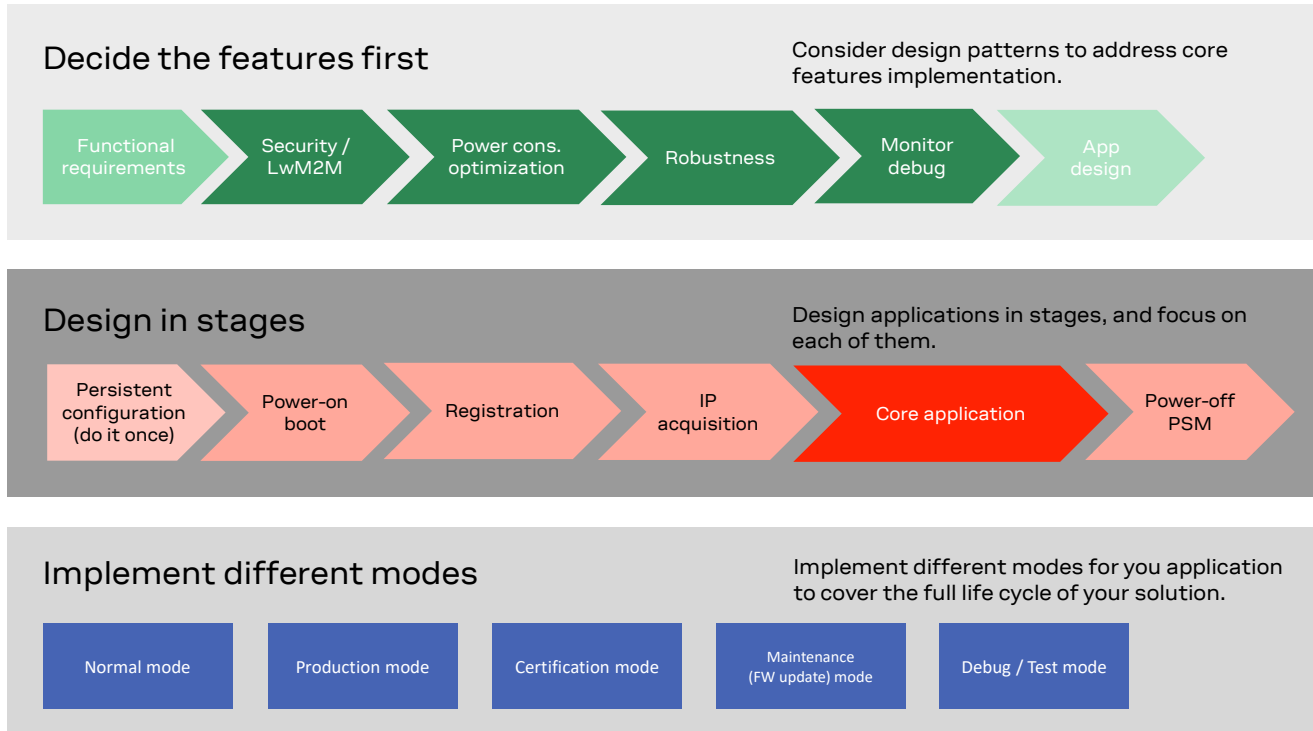
Figure 2: Application design guidelines

2.1 Initial design decisions and recommendations

Features not used during the application lifetime shall be disabled or properly configured to minimize their impact on the overall performance. Carefully decide at design stage, as later changes can cause much effort to adapt and validate the application.

These decisions concern:

- Use of an LwM2M client
- Use of security suite features
- Use of power saving
- AS-RAI feature configuration
- SIM card/MNO selection
- SW/HW monitor and debug solutions
- SW/HW recovery modes.

LwM2M client

The LwM2M is:
- Enabled by default in the SARA-R42 "00B" product versions.
- Disabled by default in the SARA-R42 "01B" product version apart from the Verizon MNO profile, i.e. in the "+UMNOPROF:3" configuration.
- Disabled by default in the LEXI-R422 modules.

An LwM2M client is necessary so that MNOs can contact the device and retrieve diagnostic information. It also enables automatic periodic checking of FOTA update availability, on both MNO and u-blox servers. Based on the target power consumption profile, the customer application can periodically enable the client to control features, such as the periodic LwM2M registrations with the server, or it can implement alternative or additional methods to implement FW updates when triggered by prolonged out-of-service conditions or by specific events.

Security suite features

Security client, if not in use, could be disabled by applying:

```
AT+CFUN=0
AT+USECMODE=0
AT+CFUN=16 //module reboot for saving NVM settings
```

On SARA-R42 series modules, this AT commands sequence could be issued if the module is still in the `+USECDEVINFO: 1,0,1` status and the security sealing has not been performed.

☞ On SARA-R422M10S-01B-01 and SARA-R422S-01B-01 modules, the security client is disabled by default.

☞ On SARA-R422M10S-01B-02, SARA-R422S-01B-02 and LEXI-R422 modules, the security suite features are not supported.

Power saving features

Power saving features (`+UPSV`, PSM, eDRX) shall be configured based on the target power consumption profile, see section 7.

AS-RAI feature

If these power saving features are not in use, it is suggested to disable the Access Stratum Release Assistance Indication (AS-RAI) feature to improve the module interoperability towards MNOs. The AS-RAI can be disabled by applying:

```
AT+UDCONF=92,19,0
AT+CFUN=16 //module reboot for saving NVM settings
```

SIM card / MNO selection

The MNO profile to be used depends on the type of application and SIM card (regional or global roaming). If the SIM card belongs to an MNO for which the module has gained the type approval, the MNO profile is available in the FW and shall be used. For more details, see section 5 and the corresponding data sheet [2][3].

SW/HW monitor, debug and recovery modes

You can debug the module via test endpoints, access to the USB interface, and in general the application log of AT command history, including diagnostic information sent by the module. Monitoring the module status is required to implement recovery procedures via HW or SW, as described in section 8.

u-blox recommends properly design and test of a module's firmware update mechanism that allows deployment of the latest cellular module FW in the field after the device production.

☞ It is suggested to disable the LwM2M and security clients, especially if the related features are not explicitly required by the MNO and not needed by the user.

☞ It is highly recommended to always read the indications and workarounds provided in the official product notifications, i.e., Information Notes (IN), Product Change Notes (PCN), etc. This makes the customer application implementation, handling and validation easier.

2.2 Application stages

2.2.1 Persistent configurations

Some module settings are persistent, that is, they are stored in the module's non-volatile memory (NVM). Among these are the MNO profile, APN for Internet connectivity, and active LTE bands.

The host application should implement a persistent configuration setting phase, performed once and then at an as-needed basis, where all AT commands related to the required settings are issued.

☞ See the FW update application note [6] for persistence of settings after a FW update. If settings are not retained, they shall be reapplied, see section 2.2.2.

2.2.2 Power on/boot/PSM exit

In general, at each boot, the application should verify the configurations. If verification failed, the persistent configurations can be reapplied.

Not all the module configurations are persistent. Therefore, the application, after each module boot, should again set these volatile configurations. For example, AT+CMEE=2, URC enabling.

It is important that the application has a robust mechanism to detect when the module is ready to communicate via AT commands at the power-on. One solution is to enable the greeting message (+CSGT AT command); alternatively, the host application can wait for a response to "AT" command.

☞ When using PSM, at exit from low power mode, the volatile settings and the current communication port mode (MUX, dialup) shall be restored too.

2.2.3 System time

The application shall configure module's time to keep this information updated, because of its importance and its consequences on the overall system behavior.

There are several ways to set the current date and time on cellular module:

* If an updated time is available at host side, the application could set the module time through the +CCLK AT command at booting time.
* Automatic update of local time through the Network Identity and Time Zone (NITZ) feature, if supported by the selected MNO. In particular this action is automatically performed and it is related to the +CTZU AT command settings. When the time zone update is enabled and the MNO supports the NITZ feature in its procedures (e.g. network attach), the module time is automatically updated and its value could be checked through the +CCLK AT command; be aware that NITZ information are sent only at first registration, so it is recommended to perform a detach/attach cycle after enabling the automatic time zone update via NITZ.
* If a GNSS receiver is available and accessible in the system architecture, the application can retrieve the UTC time from GNSS through the +UGTMR AT command, the +CCLK value is then automatically updated. Be aware that the time zone must be manually set.
* The application could implement a specific functionality (e.g. based on sockets) to retrieve time information from suitable time servers and then set the module time by the +CCLK AT command.

☞ SARA-R42 "00B" product version: +CTZU factory-programmed value is 0, i.e., automatic time zone via NITZ as disabled.

☞ SARA-R42 "01B" product version and LEXI-R42 series modules: +CTZU factory-programmed value is 1, i.e., automatic time zone via NITZ as enabled.

2.2.4 Network registration

For details about the network registration stage, see section 6.

2.2.5 IP acquisition

For more details, see the Internet applications development guide application note [9].

2.2.6 Core application

For more details, see the Internet applications development guide application note [9] and the AT command manual [1]. The application shall handle AT commands, responses and unsolicited indications as suggested in section 3. For diagnostic purposes, the application shall rely on status AT commands, see section 8.1. For robustness purposes, the application shall implement embedded watchdog procedures, see section 8.2.

2.2.7 Power-off

The application may need to switch off the module. Both normal and emergency shutdown are described in the corresponding system integration manual [4][5].

2.3 Application modes

An application is usually designed based on the main use scenarios. This way of operation is called "normal mode". In addition, the designer shall provide a way to configure the application for more specific contexts, which can have different requirements with respect to normal mode and can help to perform other important steps in the product lifecycle.

2.3.1 Debug / test mode

In general, an application should always output a significant log, including the AT commands it issued and their responses, and implement monitoring strategies as described in section 8.

If a problem occurs related to the cellular module and more information is needed, it may be necessary to configure different verbosity levels for the host application and modules log. This can be done with configuration files, that can be side-loaded to the file system. In extreme cases, it may be necessary to provide an AT interface passthrough to allow access to diagnostic AT commands.

If the cellular communication is tested against a network simulator, use a suitable test SIM card (usually provided by the network simulator manufacturer). If a test SIM card is not available, make sure to disable authentication and integrity checks on the tester side and on the module (by using the AT+UDCONF=81,0 command, see the AT commands manual [1]).

2.3.2 Production testing

This mode is to be used during the production tests of the end device. In this scenario the main application is usually inactive, and AT commands can be used to properly configure the module and use its end user testing features as described in the corresponding production and validation test app note [7][8].

2.3.3 Certification mode

Depending on the kind of certification, such as regulatory, conformance or for MNO type approval, the application might be disabled, and the module externally controlled (for example, for throughput

testing). Specific MNO tests might require the application to be running in normal mode (for example, remote SIM provisioning, FOTA).

2.3.4 Firmware update mode

A module's firmware update shall be implemented when necessary, either over the air or tethered. Each update strategy has its requirements and correct implementation, which must be followed to guarantee the success of the operation. See the FW update application note [6] for more details.

3 AT commands response parser

It is important that the user implements a dedicated AT parser component in the host application.

Basic guidelines:

* When entering AT commands, spaces are ignored.
* The DTE shall handle the case of unexpected spaces or line endings, i.e. the `<CR><LF>` characters.
* As suggested in the series AT commands manual [1], always wait for at least 20 ms following a final result code or a URC reception before issuing a new AT command.
* When the module has finished processing an AT command, it will output a final result code (either OK or ERROR) indicating that it is ready to accept a new AT command. The information text responses are issued before the final result code. Change `+CMEE` setting to numeric or verbose value (i.e., `AT+CMEE=1` or `AT+CMEE=2`).
* Asynchronous commands, e.g., `+UMQTTC`, return an immediate final result code and final result via URC.
* Some AT commands return an intermediate result code (IRC) during command execution.

☞ Due to interface restrictions, when using multiple AT command interfaces, in LEXI-R422 and SARA-R42 series modules, the parser cannot have parallel activity on two or more AT terminals. This behavior can be detected in the following configurations:

  o Double UART availability, i.e. `+USIO:1`;
  o Virtual channels set through multiplexer (MUX).

The only allowed parallel activity is present when it is defined a system architecture with a PPP dial-up on one port and AT commands on the other one.

3.1 Operational modes of the AT interface

When implementing the AT parser, it is important to consider that the communication port, whether the main UART or a MUX virtual port, enters different operational modes while processing AT commands.

In command mode, the data communication equipment (DCE), i.e., the module, can receive AT commands. Once an AT command is detected on the AT interface, the DCE processes it and may return to command mode by issuing a success or error response. Special AT commands lead the AT interface into intermediate states where, for example, an SMS payload is expected, or raw/binary data is exchanged (for example, during file transfer), or PPP packets are exchanged. In the latter case, the PPP data mode can be temporarily exited by a special `+++` packet or DTR line ON-to-OFF transition and the online command mode (OLCM) state is entered: from this state, which is similar to the command mode, the DCE can be moved back to PPP data mode via `ATO` command or can disconnect PPP via `ATH` command (having previously applied `AT+CVHU=0` as mandatory setting).

Figure 3 depicts the various modes in which the module can operate and shows the actions that cause transitions between the different modes. The transitions triggered by DTR line changes are configurable with the `AT&D` command, see the AT commands manual [1].
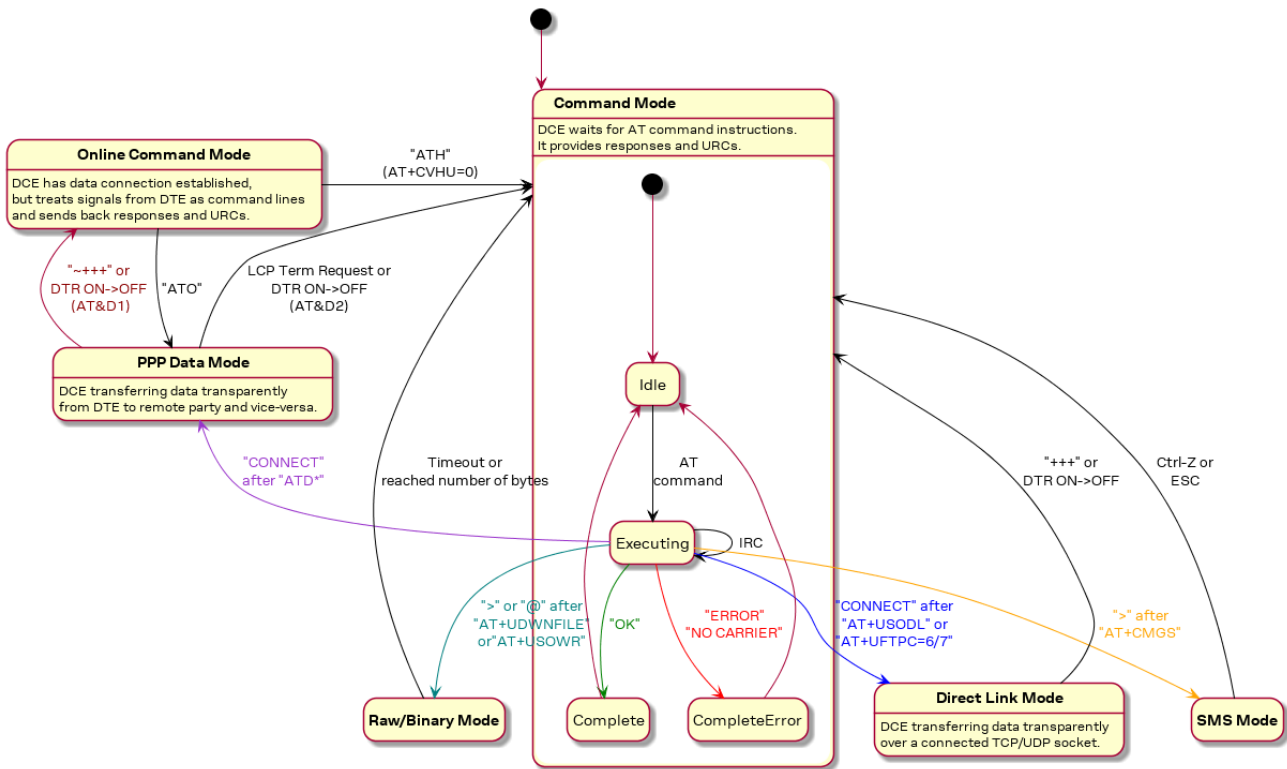
Figure 3: Module operating modes and actions causing mode transitions

3.2 Unsolicited result code

An unsolicited result code (URC) is a string message (provided by the DCE) that asynchronously indicates the occurrence of an event that might be related to a previous AT command or to the feature the user is currently using, or to the module's autonomous activity (for example, due to mobility).

When enabled on a given AT port, the URC can be output at any time to report a specific event or status change on the same AT port. If the AT port is busy, the application can discard +CIND, +CGEV and SMS related URC by properly configuring the related AT commands; all other URCs will be deferred and printed when the AT port returns into command mode.

By default, all AT ports are enabled for the reception of URCs, it is possible to exclude some of them, by the +UURCCONF AT command available in SARA-R42 "01B" product version and LEXI-R422 modules. For more details, see section 3.2.1.

☞ Due to race conditions in mode transitions, URC can be received after an AT command has been transmitted by the host application.

☞ URCs are sent to all available AT interfaces when the multiplexer functionality is applied.

Table 2 shows URC examples.

URC	Description
+CEREG: <stat>[,<tac>,<ci>,<AcT>]	Network registration status or location has been updated
+CGEV: ME PDN ACT <cid>[,<reason>[,<cid_other>]]	The MT has activated a primary PDP context
+ULWM2MSTAT: <event>,<param1>[,<param2>]	LwM2M URCs generic syntax
+UUSOCL: <socket>	Socket has been closed

Table 2: URCs examples

3.2.1 URC over AT terminal configuration

The +UURCCONF AT command configures the list of the AT terminals enabled for URC reception.

This AT command is available in SARA-R42 "01B" product version and LEXI-R422 modules and shall be used by any application that is requiring URCs to be displayed only a specific set of AT terminals.

☞ The +UURCCONF is volatile and is reset to its factory-programmed setting at each reboot.

Command	Response	Description
Enabling the feature at each module reboot		
AT+UURCCONF=2	OK	The feature is active, and URCs are disabled on all terminals.
AT+UURCCONF?	+UURCCONF: 2,0,0 OK	The read command confirms that the feature is active, and no AT terminal is enabled for URC display.
AT+UURCCONF=1	OK	The AT terminal on which the AT command has been given is now enabled for URC display.
Read example		
AT+UURCCONF?	+UURCCONF: 1,1,1 OK	The read command given on an URC enabled AT terminal confirms that the latter is in the list.
AT+UURCCONF?	+UURCCONF: 1,0,1 OK	The read command given on a different AT terminal confirms that the latter is not in the list and hence it is not enabled for URC reception.
Disabling the feature		
AT+UURCCONF=0	OK	The feature is disabled, URCs will be displayed on all active AT terminals.
AT+UURCCONF?	+UURCCONF: 0,0,0 OK	The read command confirms that the feature is disabled.

Table 3: +UURCCONF AT command example

☞ The +UURCCONF AT command is not supported by SARA-R42 "00B" product versions.

4 Local connectivity

4.1 Serial interface configuration

Use AT+USIO command, to switch between 3 serial interface configuration variants, see Table 4.

Command	Response	Description
AT+USIO=0	OK	(Default configuration) AT on UART (9-wire: RXD, TXD, CTS, RTS, DTR, DSR, DCD, RI, GND), trace on USB.
AT+USIO=1	OK	AT on UART and AUX UART (5-wire: RX/TX, HW flow control, GND), trace on USB.
AT+USIO=2	OK	AT on UART and AUX UART (5-wire: RX/TX, HW flow control, GND), trace on AUX UART.
AT+USIO=4	OK	AT on UART (5-wire: RX/TX, HW flow control, GND), GNSS tunneling on AUX UART (5 wire: RX/TX, HW flow ctrl, GND), trace on USB.

Table 4: USIO variants description

☞ Reboot the module to apply the new USIO configuration. For more details on +USIO AT command, see the series AT commands manual [1].

☞ AT+USIO=2 option is supported by SARA-R42 "01B-01" and "01B-02" type numbers and LEXI-R422 modules.

☞ AT+USIO=4 option is not supported by SARA-R422 modules.

☞ URCs are sent to both UART and AUX UART interfaces when the AT+USIO=1 option is set.

☞ It is not possible to have parallel activities on both AT terminals when the double UART configuration is selected, i.e. in AT+USIO=1. The only allowed parallel activity is present when it is defined a system architecture with a PPP dial-up on one port and AT commands on the other port.

☞ The +URINGCFG AT command is not applicable when the AT+USIO=1 option is selected due to the fact that the RING line is not available at UART level in this configuration.

4.1.1 Auxiliary (AUX) serial interface configuration

If the AUX UART interface is enabled via the +USIO AT command, then it may be necessary to properly configure this serial interface from the main UART interface, especially for the first use and whenever the factory-programmed configuration does not match the desired settings.

☞ Configuration changes are stored in the NVM and applied to the AUX UART interface at the next module boot.

Table 5 shows examples of the +UUARTCONF AT command configuration.

Command	Response	Description
AT+UUARTCONF=1,115200,3	OK	Set the desired baud rate and flow control mode for the auxiliary UART interface.
AT+UUARTCONF?	+UUARTCONF: 0,115200,3 +UUARTCONF: 1,115200,3 OK	Check the current settings for both the main UART and the auxiliary UART interfaces.
AT+UUARTCONF=?	+UUARTCONF: 1,(9600,19200,3 8400,57600,115200,230400,46 0800,921600),(0-3) OK	Visualize the possible settings to be applied in the auxiliary UART handling.

Table 5: +UUARTCONF variants description

☞ The "Set" command is available only for the auxiliary UART interface.

☞ The "Read" command is available for both the main UART and the auxiliary UART interfaces.

☞ Baud rate 921600 bit/s is not supported by SARA-R42 "00B" product version.

4.2 AT interface

AT commands can be issued to the module only via UART interface.

By default, the UART data rate is set to 115200 bit/s. Autobauding is not supported by SARA-R42 / LEXI-R422 series modules.

4.2.1 Set a fixed baud rate

Table 6 shows how to set a different baud rate for the main UART by the +IPR AT command.

Command	Response	Description
AT+IPR=57600	OK	Set UART speed to fixed value 57600 bit/s.
		Cellular module response is sent at 115200 bit/s, i.e. at the original baud rate value.
After the "OK" final result code, wait for at least 200 ms before issuing a new AT command, to guarantee proper baud rate reconfiguration. Then send commands at the speed just set (57600 bit/s in the example).		
The new selected baud rate is immediately applied, a device reboot is not needed.		
AT+IPR?	+IPR:57600 OK	Check the current baud rate

Table 6: Setting a fixed baud rate example

☞ The UART speed takes around 200 ms to reconfigure itself after a baud rate change through the +IPR AT command.

☞ To show a greeting text at module boot (+CSGT AT command), set the desired fixed baud rate beforehand by using the +IPR AT command. If active, the greeting text is shown at boot once, on any AT interface, the first time the TE sets the DTR line to ON state.

☞ If using the Direct Link mode in downlink, it is advisable to apply 460800 bit/s as fixed baud rate.

☞ Baud rate 921600 b/s is not supported by SARA-R42 "00B" product version.

4.3 Multiplexer (MUX)

LEXI-R422 / SARA-R42 series modules support the multiplexer functionality on the UART physical link as defined in the 3GPP TS 27.010 [17]. This makes it possible to have multiple simultaneous sessions (virtual channels) over the single UART interface.

The following virtual channels are defined:

- Channel 0: multiplexer control.
- Channels 1 to 2: AT commands / data connection.
- Channel 3: GNSS data tunneling (NMEA).[1]

For further details about the use of multiplexer, see the Mux implementation in cellular modules application note [11].

---

[1] Not supported by SARA-R422 modules

☞ The UART interface takes around 200 ms to reconfigure itself after the multiplexer configuration through the +CMUX AT command.

☞ It is not possible to have parallel activities on AT terminals when the multiplexer is activated through the +CMUX AT command. The only allowed parallel activity is present when it is defined a system architecture with a PPP dial-up on one port and AT commands on the other port.

☞ URCs are sent to all available AT interfaces when the multiplexer functionality is applied.

☞ The multiplexer protocol is not supported in the configurations having the AUX UART interface enabled (for example, +USIO: 1, +USIO: 4).

4.4 Point-to-point protocol (PPP)

Data (PSD) calls are possible over both primary UART and auxiliary UART interfaces.

☞ If the double UART configuration is used, the full V24 modem lines are not supported. In this configuration, entering in OLCM or disconnecting the PPP connection via DTR line de-assertion is not possible.

☞ Issue the AT+CVHU=0 command to make ATH over Online Command Mode (OLCM) work, according to 3GPP requirements. If the module has a DUN/PPP activated and is in OLCM, the command deactivates the PPP and the associated PDP context (if possible).

Further information about PPP dial-up establishment can be found in the Internet applications development guide application note [9] and in the EVK-R4 user guide [14].

4.5 Generic guidelines

To properly configure local connectivity, take the following steps:

1. Set the required connectivity variant at first use, via the +USIO AT command.
2. Configure the GPIOs based on the set variant (especially in reference to the **RI** line), via the +UGPIOC AT command.
3. Configure the power saving control mode based on the set variant, via the +UPSV AT command. Moreover, in power saving configurations, it is advisable to set the RING line through the +URINGCFG AT command for asserting this line to properly detect incoming SMS and incoming data (PPP, sockets, FTP in Direct Link mode). This prevents from losing data when the power saving is enabled, i.e.:
   o The DTR line is de-asserted, if the AT+UPSV=3 is applied.
   o The AT inactivity timer (6 secs) expires if the AT+UPSV=4 is applied.

5   MNO profiles

MNO profiles provide a powerful and flexible method to configure the modules to seamlessly work with the SIM of the selected network operator.

Using the MNO profiles the module is dynamically configured to use the proper bands, RATs, and the operator-dependent protocol stack settings needed to operate on the home network in full compliance with the mobile operator requirements.

With the MNO profiles, a customer application is not required to configure the module using complex and/or network-dependent parameters but benefits from a "out of the box" solution that provides seamless connectivity while abstracting the complexity of managing individual network configurations.

Use the `+UMNOPROF` AT command to select a profile for the network operator. For more details of the `+UMNOPROF` AT command and the MNO profile settings, see the AT commands manual [1].

5.1   Using MNO profiles

To configure the module to use an MNO profile, first make sure the module is de-registered from the network, then select the profile using the ID number and finally software-reset the module. When the module reboots, it will configure itself to use the parameters specified by the MNO.

☞   The host application should specify an MNO profile. The default and factory-programmed MNO profile is 90 (global profile).

☞   Reboot the module by `AT+CFUN=15` command (or the equivalent `AT+CFUN=16`) to make the MNO profile active.

5.2   Modifiable parameters

MNO profiles configure the module with a set of parameters. Some of these parameters can be overridden by using AT commands:

- `+UBANDMASK`   Band mask
- `+CGDCONT`   APN and PDP type
- `+URAT`   Radio access Technology

If the host changes any of these parameters, they will be retained after a module reset; if the MNO profile is re-applied, after reboot the MNO profile specific settings will be restored to the factory-programmed setting.

☞   Usually, the APN will be accepted also when in roaming, but bands might need to be enabled to search for alternative PLMNs.

After setting the MNO profile the application may want to also modify the Radio Access Technology list and Band Mask.

Possible reason for setting `+URAT` may include:

- Radio Access Technology is not deployed by network carrier yet in the area where devices run. Therefore, only enabling the desired RAT will reduce scan time when device is searching for the network.

☞   The US MNO profiles (AT&T, Verizon and FirstNet) activate only the LTE Cat M1 as Radio Access Technology. Accordingly, if the customer device is designed to go roaming to other countries or continents, it could be necessary to manually activate the NB-IoT and 2G RATs. Note that these

technologies have not to be used in U.S. because they are not certified for the referred network providers.

Possible reasons for setting `+UBANDMASK` may include:

- Band(s) is not deployed by carrier yet in the area device is intended to run.
- Device is an area where it is interested in running on specific bands only
- Reducing the number of bands will reduce scan time when the device is searching for the network in out-of-service or limited-service conditions.

5.3 MNO profile setting examples

Do not: set the MNO profile while the module is registered (Table 7)

Command	Response	Description
AT+CMEE=2	OK	Enable verbose error result code.
AT+COPS?	+COPS: 0,0,"00101",7 OK	Module is currently registered.
AT+UMNOPROF=100	OK	Do not set MNO profile while module is registered.

Table 7: Wrong way of setting the MNO profile

Do: de-register the module before setting MNO profile, then reboot it to apply the setting (Table 8)

Command	Response	Description
AT+CFUN=0	OK	Turn-off radio functionality, the module will de-register.
AT+UMNOPROF=100	OK	Set MNO profile for Standard Europe.
AT+CFUN=15	OK	Perform a module reset. After reboot, the MNO profile 100 settings are applied.

Table 8: Correct way of setting the MNO profile

5.4 Global profile (+UMNOPROF: 90)

This is the default profile for the SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422 modules, with all supported bands set as enabled on all available RATs (LTE-M, NB-IoT, GSM/EGPRS).

☞ The LwM2M client is disabled by default in the Global profile of SARA-R42 "01B" product version and LEXI-R422 modules.

5.5 Standard Europe profile (+UMNOPROF: 100)

The MNO profile 100 should be used as the basis for all other MNOs in Europe outside of ones explicitly referred in other profiles. However, there may be changes that need to be applied to the module for proper operation with any given MNO such as attach type, RAT preference, band selection, etc. Please consult with the preferred network provider.

If the device is attaching to a network operator, even outside Europe, that is not listed in the MNO profile list, MNO profile 100 should be used as a generic and configurable profile.

Also, it is recommended to use this profile for mobile virtual network operator (MVNO) and roaming SIMs.

☞ The LwM2M client is disabled by default in the Standard Europe profile of SARA-R42 "01B" product version and LEXI-R422 modules.

☞ In LTE Cat M1, B1 band has been added to the Standard Europe profile in SARA-R42 "01B-01" and "01B-02" type numbers and LEXI-R422 modules, so in these series the `"+UMNOPROF: 100"` configuration entails B1, B3, B8 and B20 as enabled bands.

5.6 AT&T profile (+UMNOPROF: 2)

SARA-R42 in AT&T configuration (`+UMNOPROF: 2`) is factory-programmed with a blank string for the <APN> at default context <cid>=1 as per AT&T requirement, the user must set the custom APN (which might be different for M2M and consumer SIM cards) used for live AT&T network attach via the `+CGDCONT` set command. This setting is persistent. For more details, see the AT commands manual [1].

Per AT&T requirement, LwM2M predefines a `+CGDCONT` context with factory-programmed values:

- <cid>=2: Ipv4V6,"attm2mglobal"
  - This is used for LwM2M data connection to the AT&T server for device management purposes. This APN entry shall not be deleted/changed by user.

☞ SARA-R42 is certified AT&T for LTE Cat M1 only. Accordingly in U.S. it is allowed to access only this RAT, while in roaming conditions outside North America area, it is possible to manually activate also the NB-IoT and 2G RATs and to apply desired configurations through suitable AT commands (e.g. `+URAT`, `+UBANDMASK`, etc.).

☞ The AT&T profile is not supported by SARA-R42 "00B" product version and LEXI-R422 modules.

☞ The LwM2M client is disabled by default in the AT&T profile of SARA-R42 "01B" product version.

5.7 Verizon profile (+UMNOPROF: 3)

Per Verizon requirement, the initial EPS bearer and the EPS bearers used by BIP and LWM2M are defined by default and are aligned to the entries of the VZW APN table. For more details, see `+VZWAPNE` AT command description in AT commands manual [1].

SARA-R42 in Verizon configuration (`+UMNOPROF: 3`) is factory-programmed with a blank string for the <APN> at default context <cid>=1. The proper APN for <cid>=1 (e.g. a static APN related to the UICC subscription) will be assigned by Verizon during the LTE attach and shall be primarily used for user data connectivity. The APN for the other <cid>s can be updated by Verizon via LwM2M provisioning. Table 9 lists the descriptions of <cid>s in Verizon configuration.

<cid> (context id)	Description
1	Initial EPS bearer, it corresponds to the first record of VZWAPNE.
2	Corresponds to the Class 2 record of the VZWAPNE and it is used by BIP.
3	Corresponds to the Class 3 record of the VZWAPNE.
4	Corresponds to the Class 4 record of the VZWAPNE and it is used for the VZW Application PDN.
5, 6, 7	Correspond, respectively, to the Class 5, Class 6, and Class 7 records of the VZWAPNE.

Table 9: <cid>s description in Verizon MNO profile

The +CGDCONT read command shows the EPS bearers with <cid> in range 1-7. They cannot be modified or undefined with `+CGDCONT`, nor deleted with `+CGDEL` AT command.

☞ SARA-R42 is certified Verizon for LTE Cat M1 only. Accordingly in U.S. it is allowed to access only this RAT, while in roaming conditions (outside North America area) it is possible to manually activate also the NB-IoT and 2G RATs and to apply desired configurations through suitable AT commands (e.g. `+URAT`, `+UBANDMASK`, etc.).

☞ The Verizon profile is not supported by SARA-R42 "00B" product version and LEXI-R422 modules.

☞ The LwM2M client is enabled by default in the Verizon profile of SARA-R42 "01B" product version.

5.8 GCF-PTCRB profile (+UMNOPROF: 201)

It is recommended to use this MNO profile during production or lab tests. With this profile, LwM2M is disabled.

From a regulatory perspective, MNO profiles do not affect the low-level RF performance of the module, which are the same regardless of the selected profile. Some profiles may enable features not available on a simulated network, which are known to interfere with laboratory measurements. By setting the GCF-PTCRB profile (+UMNOPROF: 201) unexpected behavior during testing is reduced.

5.9 FirstNet profile (+UMNOPROF: 206)

FirstNet is the AT&T nationwide high-speed wireless broadband network dedicated to public safety community. By setting the FirstNet profile (+UMNOPROF: 206) the interoperability with this network is optimized.

Per FirstNet requirement, LwM2M predefines a +CGDCONT context with factory-programmed values:

- <cid>=2: Ipv4V6," attiotfirstnet.fn"
  o This is used for LwM2M data connection to the FirstNet server for device management purposes. This APN entry shall not be deleted/changed by the user.

☞ SARA-R42 is certified FirstNet for LTE Cat M1 only. Accordingly in U.S. it is allowed to access only this RAT, while in roaming conditions (outside North America area) it is possible to manually activate also the NB-IoT and 2G RATs and to apply desired configurations through suitable AT commands (e.g. +URAT, +UBANDMASK, etc.).

☞ The FirstNet profile is not supported by SARA-R42 "00B" product version and LEXI-R422 modules.

☞ The LwM2M client is disabled by default in the FirstNet profile of SARA-R42 "01B" product version.

6 Network registration

At power-on the module reads the information in the currently selected MNO profile. It will use this information to configure which bands to scan, the radio access technology to use if more than one is supported, and other attach parameters like APN.

Once the module has found a suitable cell to camp on, it will start the registration process. Depending on the current PLMN, during the registration the device can be provisioned with the APN or the APN must be provided by the host application as part of the persistent settings.

A new SIM can be activated after its first registration on a real network: its "profile" (i.e. contents of the SIM files) can be remotely provisioned over the air and a registration cycle is triggered at the end of the SIM OTA procedure.

6.1 LTE Initial default bearer

LTE networks are all-IP networks, meaning all services available to the end-user rely on IP protocols.

LTE devices are "always-on", i.e., an IP address is always assigned to the device when it is registered to an LTE network. There is always an IP connection between the device and a PDN, therefore one PDP context must always be active.

The initial default EPS bearer is the PDP context enabled during the EPS attach (i.e., the network registration phase).

If no APN has been specified by the device, the network will assign a default one, the so-called anchor APN, in this way a PDP context is active, and the module has an IP address.

☞ The PDP context with the anchor APN guarantees the LTE signaling but does not assure IP connectivity to the Internet. It depends on MNO policies, e.g., it might be used by BIP or OMA-DM clients only for administrative purposes.

It is strongly recommended to use a proper APN for the initial default bearer. The APN value shall be provided by the SIM card provider.

The APN for the initial default bearer must be set when the module is in the de-registered state.

6.2 RAT selection

To select the RAT to be used by the module (LTE Cat M1, NB-IoT or EGPRS), issue the +URAT AT command.

Before changing the RAT selection, set the module to minimum functionality via AT+CFUN=0 command. To make the setting effective, reboot the module with the AT+CFUN=16 command. Table 10 shows an example of the procedure.

Command	Response	Description
AT+URAT?	+URAT: 7 OK	Query the currently set RAT. Currently selected RAT is LTE Cat M1.
AT+CFUN=0	OK	Set the modem to minimum functionality.
AT+URAT=8	OK	Change RAT selection to NB-IoT.
AT+CFUN=16	OK	Reboot the module to make the change of RAT selection effective.
		Wait for module to reboot.
AT+URAT?	+URAT: 8 OK	Query the currently set RAT. Currently selected RAT is NB-IoT.

Table 10: Example of changing RAT selection from LTE Cat M1 to NB-IoT

6.2.1 PLMN and RAT selection rules

SIM card configuration can overrule +URAT settings: in automatic PLMN selection mode (+COPS: 0), the +CPOL lists of PLMNs have higher precedence than a visited PLMN not present in such list. Therefore, a higher priority 2G PLMN can be reselected from a roaming PLMN with lower priority, even if the module is currently registered on it in LTE. In national roaming, the HPLMN will be looked for with the same procedure, periodically or when performing a AT+COPS=2/AT+COPS=0 cycles.

For more details, see section 6.7.

6.2.2 RAT automatic scan

When working in multi-RAT (LTE Cat M1 plus NB-IoT and/or 2G), it can happen that the module does not select the highest priority RAT according to +URAT settings (e.g. NB-IoT or EGPRS according to AT+URAT=7,8,9 setting) due to its current unavailability in the selected network.

Considering this aspect, SARA-R42 series modules present a functionality based on the +URATSCAN AT command that periodically triggers a network scan to look for a RAT with a higher priority than the current one. The RATs priority is defined through the +URAT configuration and the default scan time is set to 60 minutes. Note that:

- The periodic scan triggered by +URATSCAN causes a temporary out-of-service (OOS) period in which the device is not reachable, e.g. for SMSs. This must be considered by user applications, as more configured bands (see +UBANDMASK), more time to complete the network scan;
- In SARA-R42 series modules, the +URATSCAN AT command triggers a network scan also in data traffic mode, so there could be a temporary suspension of this activity.

☞ It is advisable to apply a suitable tuning at customer side: there could be a trade-off between the need to select a RAT with a higher priority and the requirement to decrease as much as possible the OOS time.

☞ In SARA-R42 "00B", "01B-00" and "01B-01" product versions, +URATSCAN is effective only when the module is registered on the HPLMN. In case +CPOL lists are empty or configured with no roaming partners in the current country, the module will not automatically search for a higher priority RAT: in this case the host application can periodically suspend data traffic and trigger the higher priority PLMN and RAT search with AT+COPS=0 command.

☞ In SARA-R42 "01B-02" and LEXI-R42 product versions, +URATSCAN can be enabled also in roaming conditions by a new parameter called "roaming_mode" available in the AT command definition.

6.3 Band configuration

The module can scan over several bands to find a network to attach to. The host application can limit the scanning to specific bands to shorten the time to find a network.

Use the +UBANDMASK AT command to specify these bands as an 8-byte bitmask. In the bitmask, setting the bit at (band-x) position to 1 enables the scan of band x, as shown in Figure 4.

Bands	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	SUM	BITMASK
Base 2	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	SUM	BITMASK
Enable B20 only	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2^{19}	524288
Enable B2,B4,B5,B12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	$2^{11}+2^4+2^3+2^1$	2074
Enable B4, B13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	$2^{12}+2^3$	4104

Use these values for AT+UBANDMASK

Figure 4: +UBANDMASK bitmask creation examples

☞ Each MNO profile defines a set of bands to scan on.

6.3.1 Scan time

LEXI-R422 / SARA-R42 series modules will scan each band configured for each RAT selected. By reducing the number of bands and selecting only one RAT, the module may attach to a network faster.

Because NB-IoT allows cells to be found with much higher dynamic range, the scan time in NB-IoT is much longer than LTE Cat M1. If the application has configured NB-IoT as well as LTE Cat M1, but there are no NB-IoT networks, the module may take a few minutes per band to complete the NB-IoT scanning before re-trying the LTE Cat M1 RAT scan. If a global roaming profile is used, the application can rely on the automatic band scan and PLMN search done by the device at national border crossings. Alternatively, to optimize power consumption and reduce the impact of band scan and PLMN searches in out of coverage situations, the application shall reduce the supported bands based on regional information provided by the module via AT command interface and change bands with some hysteresis.

Regarding the possibility to perform network scans when the module is in automatic selection, i.e., AT+COPS=0, the following points must be considered, especially in roaming conditions:

- The RATs are considered according to the +URAT AT command settings about the preference order (<1stAcT>, <2ndAcT> and <3rdAcT>);
- The preference order of the RATs could be overruled by the +CPOL preferred operator list and the related <AcT>.

6.3.1.1 OOS scan timings

The scan algorithm is implemented when attempting to gain service at power-up and when the out-of-service (OOS) condition is detected. A full system scan is interspersed with sleep intervals to reduce power consumption. The algorithm starts with a sleep time of 30 s which is applied 10 times, then the sleep time is incremented to 45 s, which again is applied for another 10 times, finally the sleep time is set to 60 s.

Each full system scan starts with the search of recently used cells, if available, which are coming from an internal database updated every time the devices find full service on a cell. Then the full system scan continues triggering a band scan for all enabled bands. At each step, the full scan considers all the enabled RATs ordered according to the configured relative priority. RAT and band settings can be configured with the +URAT and +UBANDMASK AT commands if not locked.

This algorithm is maintained until a suitable cell providing full or limited service is found and the device can camp on it.

To lower the power consumption, it is recommended to implement an algorithm on the application processor to switch the device off (or set it to minimum functionality) if it cannot gain service for a long time and switch it on (or set it to full functionality) after a while to try to get full service again. The duty cycle can be selected by the host application based on the tradeoff between power consumption and maximum tolerable delay before regaining cellular coverage.

6.4 First time registration setup

It is important to set the MNO profile first because this operation will configure the default RAT and band mask for the corresponding profile. If the +UMNOPROF set command is issued after the +URAT or +UBANDMASK AT commands, it will override any configuration the host application has made. The module is programmed with auto-cops, so no AT command is required to trigger the network registration.

☞ AT+CFUN=0/1 can be used to trigger a registration cycle with switch-off detach (which does not need the DETACH_ACCEPT message from the network). A detach of type normal can be obtained with the AT+CGATT=0 command.

☞ The `AT+COPS=2/0` cycle shall be used when looking for a more suitable PLMN, as per SIM settings related to the preferred operator list available through the `+CPOL` AT command.

☞ The `AT+COPS=2/0` cycle triggers a high priority PLMN scan, so this cycle shall be avoided in roaming conditions.

6.4.1 PAP/CHAP

If PAP or CHAP authentication is to be configured, the `+UAUTHREQ` AT command shall be entered.

If the authentication is required on the initial default bearer, the setting shall be entered in de-registered state.

6.4.2 Change of PDN settings (APN name and PDP type)

To change the PDN settings for the initial default EPS bearer established during LTE attach, edit the `<cid>=1` PDN by the `+CGDCONT` AT command, as shown in Table 11.

Command	Response	Description
`AT+CFUN=0`	`OK`	Turn off the modem radio so to de-register the module.
`AT+CEREG=2;+CGEREP=2,1`	`OK`	Enable a set of registration URCs.

`AT+CGDCONT?`	`+CGDCONT: 1,"IPV4V6","","0.`
	`0.0.0 0.0.0.0.0.0.0.0.0.0`
	`.0.0.0.0",0,0,0,2,0,0,0,0`
	`,0,0`
	`OK`
		Read IP type and APN for EPS attach bearer.

`AT+CGDCONT=1,"IPV4V6","cust` `om_APN"`	`OK`	Set APN name ("custom_APN" for example) and the PDP type ("IPV4V6" for example) for EPS attach bearer.

`AT+CFUN=1`	`OK`
	`+CEREG: 1,"0001","01a2d001"`
	`,7`
	`+CGEV: ME PDN ACT 1`
		Turn on the modem radio.
		URCs indicate the registration status change.

Table 11: Change of PDN settings example

6.4.3 Attach types

All profiles use combined attach (CS & PS), if successful, both data and SMS services are allowed. If LTE attach is successful for EPS only services, still SMS can be supported (the so called "SMS only" case). If LTE attach is not successful for SMS, the module can try registration on a different RAT (e.g. 2G RAT).

The `+USVCDOMAIN` AT command can be used to change how the module attaches to the network if the factory-programmed attach type is not accepted by the network.

6.4.3.1 NB-IoT networks: ePCO handling

On NB-IoT, where CP CioT EPS optimizations are mandatorily active, the 3GPP standard prescribes that the extended Protocol Configuration Options (ePCO) container is used in Network Access Stratum (NAS) messaging when attaching to an LTE network. Some NB-IoT mobile operators do not support ePCO container. Therefore, if ePCO is used in the attach for such a network, this will result in lack of DNS capabilities. For example, for NB-IoT networks known to not support ePCO, or when `+CGCONTRDP` AT command does not return any DNS in NBIoT, it is recommended to use `+UCFGCIOT` AT command to disable the ePCO feature and fallback to PCO negotiation, as shown in Table 12.

Command	Response	Description

`AT+COPS?`	`+COPS: 0,0,"NB-IoT Network"`
	`,8`
	`OK`
		Module registered on NB-IoT network.

Command	Response	Description
AT+CGDCONT?	+CGDCONT: 1,"IP","default", "192.168.20.2",0,0,0 OK	The module activated the EPS bearer with a valid IP address.
AT+CGCONTRDP	+CGCONTRDP: 1,5,"default"," 192.168.20.2","192.168.20.1 ","" OK	DNS references not available in the +CGCONTRDP AT command.
AT+UCFGCIOT=3,0	OK	Disable the ePCO feature through the +UCFGCIOT AT command.
AT+CFUN=15	OK	Reboot the module to apply the configuration.
AT+COPS?	+COPS: 0,0,"NB-IoT Network" ,8 OK	Module registered on NB-IoT network.
AT+CGDCONT?	+CGDCONT: 1,"IP","default", "192.168.20.2",0,0,0 OK	The module activated the EPS bearer with a valid IP address.
AT+CGCONTRDP	+CGCONTRDP: 1,5,"default"," 192.168.20.2","192.168.20.1 ","185.215.195.114" OK	DNS references now available in the +CGCONTRDP AT command.

Table 12: ePCO feature disabling

6.4.4　Radio Policy Manager

LEXI-R422 / SARA-R42 series modules implement the Radio Policy Manager (RPM) feature according to GSMA connection efficiency TS 34 [18]. RPM aims to prevent cellular devices to aggressively try registration or PDP context activation procedures in case of permanent failures (e.g. "invalid UE" or "EPS services not allowed"), which are usually due to subscription restrictions, in addition to standard 3GPP retry algorithms. Since these aggressive behaviors can cause network overload and service outage, some MNOs require to have RPM active by default: the RPM feature is enabled only on specific MNO profiles, but they can be enabled via AT commands on other MNOs requiring it. For more details, see appendix C of the AT commands manual [1].

6.4.4.1　Management of SW resets

RPM limits the number of user-initiated module resets per hour following a permanent attach reject cause. RPM might block the following AT commands and provide an error result code: AT+CFUN=15, AT+CFUN=16, AT+CFUN=19, AT+CFUN=1,1 and AT+CFUN=4,1, and AT+CPWROFF.

Eventually, RPM will again allow these commands and can even autonomously trigger a SW reset: timers and maximum counters can be derived from the MNO SIM card (so they can be even OTA updated) or are retrieved from the NVM (at most 1 module reset per hour is usually allowed per GSMA). RPM counters are cleared after a successful registration.

6.4.4.2　Management of PDP context activations

RPM also limits:

- The maximum number of successful PDP context activations on the same APN (e.g. for Deutsche Telekom (DT) MNO the limit is 30).
- The maximum number of PDP context activations requests per hour following a PDP context activation request ignored by the network (e.g. for DT it is 60).
- The maximum number of PDP context activations requests per hour following a PDP context activation request rejected with a "permanent" or a "temporary" reject cause, e.g. for Deutsche Telekom they are 30 and 60 respectively.

If PDP context activation is blocked by RPM, the AT+CGACT=1,<cid> command will fail with an error result code and the dial-up on a non-active <cid> will not be established.

Since the LTE attach usually implies a PDN connectivity activation, also LTE registration cycles triggered, for example by `AT+CFUN=0/1`, are subjected to the same limitations (e.g. for Deutsche Telekom maximum 30 attach/detach cycle per hour are allowed). However, once the limit is exceeded, the module will not register to the network for the following hour and no specific error will appear.

6.5 +UMACQOSTMR timer configuration

The `+UMACQOSTMR` AT command allows configuration of a proprietary MAC layer timer that acts as an additional mechanism that can be enabled to ensure LTE network local RRC release and return to idle after prolonged RX and TX inactivity of the radio channel. It is referred as an "additional back-up mechanism", since the RRC procedure would normally handle the local RRC release. However, if there is a rare instance that it does not release timely with a network, this mechanism provides added reliability. An optimal and timely local RRC release is important to ensure the proper handling of any potential inbound network pages.

For details on the default `+UMACQOSTMR` settings, see the MNO profiles section in the appendix of the AT commands manual [1].

When using network simulators, to perform certain types of measurements there may be a need to stay in local RRC connected state. See the corresponding production and validation test app note [7] [8], for guidance to disable the timer in such situations.

6.6 Registration monitoring

Use the `+CEREG` AT command to confirm the module is registered on the LTE network for LTE Cat M1 or NB-IoT. Use `+CREG` and `+CGREG` AT commands for CS and GPRS network registration status.

When registering on an LTE Cat M1 or NB-IoT network, the PDN context will be automatically created and activated; for 2G networks the host shall manually activate the PDN context using the `+CGACT` AT command.

☞ Independently of the selected RAT, always issue the `AT+CGACT=1,<cid>` command on used context `<cid>` even if the `+CGDCONT` AT command returns that the context is still active with a valid IP address. This is highly recommended to activate the PS data connection avoiding possible conflicts between applications.

☞ If the uFOTA is enabled and needs to contact the uFOTA server when running on 2G RAT, the LwM2M will automatically activate the default context.

6.6.1 Detecting the access technology

LEXI-R422 / SARA-R42 series modules can connect to different types of access technologies, i.e. LTE Cat M1, NB-IoT and GPRS. Because the modules can be configured to automatically connect to any of these access technologies, there are AT commands the host application can use to detect what technology is being used.

The best AT command to use is the `+COPS` AT command. The `+COPS` AT command has a `<AcT>` parameter which describes the access technology the module is registered to. However, this command does not provide a URC when the module is registered.

There are other AT commands that do have a URC when the registration is made. These also describe the access technology, i.e. `+CEREG` for LTE (Cat M1 or NB-IoT) and `+CGREG` (GPRS).

Host applications should always enable the URC for `+CEREG` and `+CGREG`. When the module registers on the network the application can read the access technology type from these URCs.

Basic operation are:

Command	Response	Description
AT+CEREG=1	OK	Set URC for LTE (apply AT+CEREG=2 for more detailed info)
AT+CGREG=1	OK	Set URC for GPRS (apply AT+CGREG=2 for more detailed info)
<Wait for URC>		
AT+COPS?	+COPS: 0,0,"Cat-M1 Network",7 OK	Read +COPS and check <AcT> parameter for RAT

☞ +CREG is used to describe if the module has been registered in the Circuit Switched Domain too for combined attach modes, accordingly it is advisable to enable the +CREG URC too, by the AT+CREG=1 command or, alternatively, the AT+CREG=2 command for more detailed information.

6.6.2 PS connections at RAT change

If the module registers in LTE Cat M1 and NB-IoT networks, it will automatically activate the default bearer PDP context, <cid>=1. Any other PDP context the host has configured shall be manually activated. If the module attaches on the 2G network, this might require the host to manually activate a PDP context, unless the module reselected 2G from LTE Cat M1 or NB-IoT, where it already had an IP address whose assignment has been maintained on the 2G RAT.

When the module changes the RAT in registered state, the module will usually experience a temporary OOS condition while it is synchronizing with the new cell of the different RAT. This condition is reported via the +CGEV NW DETACH URC and +CGATT:0 PS status, but PDP contexts and socket connections are just suspended and +CGDCONT? read command will return the assigned IP addresses and +CGACT? the active PDP contexts.

6.7 Mobility scenarios

Devices used in non-static installations can move out of range of the current serving cell. This means entering another cell of the RPLMN (registered PLMN), or of a different PLMN, or moving into an area where there is no coverage, or no roaming agreement for the device.

If the module loses the synchronization with the serving cell but finds another cell of the same PLMN to camp on, any PDP context and open sockets will be kept. This holds for seamless change of serving cell with cell reselection or handover procedures.

6.7.1 Roaming conditions

If mobility implies crossing national borders or changing the PLMN, it is likely that the new PLMN will force the module to reattach. This can also occur on the RPLMN, for example, when the network needs to refresh IP addresses. If the module reselects a 2G cell and registers on a 2G PLMN, it is necessary to re-establish the PDP context to restore the services requiring cellular connectivity.

If UE is to do data traffic in roaming conditions and based on the SIM card contents there might be a higher priority PLMN in the same country (i.e., with the same MCC as the current RPLMN), then 2 minutes after the first registration, and at periodic intervals whose duration is retrieved from the SIM card (about 1 hour in 2G), the device will schedule a PLMN search to find a better roaming partner. This might lead to temporary unavailability of the cellular connectivity (for about 60 seconds in LTE Cat M1, 15 seconds in 2G and some minutes in NB-IoT) and can be handled by the host application in different ways depending on the module product variants. For more details, see section 6.7.1.1 and 6.7.1.2.

6.7.1.1 SARA-R42 "00B" product version

In the above scenario, the high priority PLMN scan (scheduled 2 minutes after the first registration and afterwards every e.g. few hours) causes the abort of the GPRS connection if SARA-R42 "00B"

module is camped on 2G, and the temporary suspension of the data traffic in all RATs as long as the PLMN scan is ongoing. In this case triggering module reboots, e.g. `AT+CFUN=0/1` cycles, is not effective to recover from data transmissions errors.

A possible solution to prevent the higher priority PLMN scan is to apply a manual PLMN selection as following:

1. Start the network registration with `AT+COPS=0` (automatic mode)

2. If the module is in roaming condition (`AT+CEREG?` or `AT+CREG?` or `AT+CGREG?` return 5 as registration status), the module shall be set in manual PLMN selection, i.e.:

   o Check the selected network in numeric format querying `AT+COPS?`

   o Manually configure the registration to this VPLMN (Visited PLMN) specifying also the current RAT in the `AT+COPS=1` instruction (e.g., `AT+COPS=1,2,"00101",7` if camped in LTE Cat M1 RAT)

3. When the module is in out-of-service condition, the automatic PLMN selection can be restored applying the usual AT commands sequence (`AT+CFUN=0; AT+COPS=0; AT+CFUN=1`) and coming back to point 1 of the proposed workaround

Alternatively, the user preferred operator list can be edited with the `+CPOL` AT command, but not all M2M SIM cards include the related file.

6.7.1.2 SARA-R42 "01B" product version and LEXI-R422 modules

In the above scenario, the SARA-R42 "01B" product versions and LEXI-R422 modules benefit from the following improvements:

* In 2G, higher priority PLMN scans are rescheduled as long as there is a running GPRS data session (more precisely, within about 1 minute since the last GPRS data packet has been exchanged with the cellular network).
* The periodicity of the higher priority PLMN search can be fully customized with the `+UHPPLMN` AT command. In detail:
  o In SARA-R42 "01B-00" type numbers the initial high priority PLMN scan is scheduled 2 minutes after the first registration and afterwards every e.g. few hours.
  o In SARA-R42 "01B-01" and "01B-02" type numbers and LEXI-R422 modules, the 2 minutes high priority PLMN initial scan is skipped if the related timeout is set by the `+UHPPLMN` AT command.
* A specific URC notifies when this search has been triggered and can be enabled in debug mode.
* In LEXI-R422 modules and SARA-R42 "01B-01" and "01B-02" type numbers, the `+USCANSTAT` AT command can be used in debug mode for detecting when the HPPLMN scan has been completed.

Command	Response	Description
`AT+UHPPLMN?`	`+UHPPLMN: 1,4320,0` `OK`	Check the +UHPPLMN AT command configuration in minutes (in this example 4320 minutes, i.e., 72 hours)
`AT+UHPPLMN=1,8640,1`	`+UHPPLMN=1,8640,1` `OK`	Set the HPPLMN search timer to 8640 minutes (144 hours), and optionally enable the URC reporting when the periodic search is triggered
`AT+CFUN=15`	`OK`	Reboot the module to apply the setting
		Wait for 8640 minutes after registration in roaming
	`+UHPPLMN: 518400`	URC visualized when the periodic search has been triggered, with indication of the last timer duration expressed in seconds

Table 13: +UHPPLMN AT command example

In general, in roaming conditions, the host application shall consider that higher priority PLMN search can occur; to keep the host application as simple as possible, we suggest applying the following procedures when working in roaming scenarios:

- Set the HPPLMN timer to a fixed value: in this way the PLMN search will occur in a periodic, predictable manner;
- Alternatively, disable the HPPLMN timer and, if required, trigger the high priority scan through the `AT+COPS=0` command entered when the module is in `+COPS:0` condition (in automatic PLMN selection mode) and at the end of the data session, to avoid any transmission interruptions.

6.7.2 Data traffic in roaming

Performing data traffic in roaming conditions could be expensive, due to possible extra costs applied by VPLMNs. In this scenario, if it is needed to limit data traffic, use `AT+UDCONF=76` command with proper syntax. In this way the selected PDP context cannot send data when roaming on a network.

6.7.3 Mobility Management procedures

Mobility management procedures are different, depending on the state of the radio connection:

- Connected Mode Mobility (CMM) is handled by the eNodeB in LTE Cat M1. The UE is instructed by the eNodeB to provide measurement reports on neighbor cells so that the network can decide if, and when, the radio resource control (RRC) connection shall be handed over to another cell.
  - The network itself will allocate gaps in the downlink transmission to allow the device to perform the intra-band or inter-band measurements: this will impact the downlink throughput.
  - If the eNodeB does not support CMM, or current RAT is NB-IoT or 2G, the RRC connection will be released at cell change due to radio link failure and it will be re-established by the device on the new selected cell. Radio link failures usually implies loss of uplink or downlink packets.
- Idle Mode Mobility is handled by the UE using information transmitted in the System Information Blocks (SIB) broadcast by the cellular network within the cell. In idle mode, the UE will make measurements of neighbor cells and, based on the cell reselection criteria read in the SIBs, it may choose another serving cell to synchronize with.

7   Deep-sleep mode, PSM and eDRX

7.1   Deep-sleep mode

Deep-sleep mode is a state in which the module keeps running at negligible current (for definitions and power consumption characterization, see the corresponding system integration manual [4][5]). The module is in minimum functionality and is not responsive to AT commands. SIM PIN check should not be used along with deep-sleep, since it would prevent cellular connectivity restore at deep-sleep exit until PIN re-insertion.

Deep-sleep mode can be enabled via AT+CPSMS=1 AT command and used in three options, described in section 7.1.4. Each feature defines the periodicity of deep-sleep entry and exit cycles autonomously performed by the module. If the autonomous wake-up would be scheduled in less than 1 minute, the UE does not enter deep-sleep to compensate for boot penalty; configuring deep-sleep for so short durations should be avoided. The host application can monitor deep-sleep entry and exit cycles, as described in section 7.1.3, and foresee them (via the +UCPSMS, +CEDRXRDP and +UPSMVER AT commands in case of PSM deep-sleep, eDRX deep-sleep and OOS deep-sleep respectively).

When the host application needs to interact with the module in deep-sleep state, e.g., to use the GNSS receiver, to issue AT commands or to send MO data, it can either wait the module to exit deep-sleep state autonomously or with a power-on event, triggering an early wake-up via the **PWR_ON** pin. From a power consumption point of view the first solution is preferred, if possible, for GNSS receiver usage and AT commands issuing, whereas the second one should be used for MO data, waking-up the module just before it exits PSM or eDRX deep-sleep by itself when possible. After an early wake-up via the **PWR_ON** pin the host application should monitor the module has exited deep-sleep state (see section 7.1.3) and interact with it immediately, in no later than 10 s after deep-sleep exit.

To keep power consumption in deep-sleep extremely low, the only running module component in this state is a low power low accuracy clock. Being this clock inaccurate, it can be affected by an always negative drift, causing the time in deep-sleep to be shortened by no more than 1% of the expected deep-sleep duration. When exiting deep-sleep the module checks the network time and can immediately re-enter in deep-sleep if convenient from power consumption point-of-view.

When the module enters deep-sleep mode it is not responsive to AT commands. In deep-sleep use cases module power-off shall be only applied when out of deep-sleep with the legacy firmware image being loaded. Network registration is kept, EPS bearers and IP addresses are also saved and restored, so MO transmission is possible as soon as the UE exits deep-sleep. Any non NVM saved settings are lost and timers, including application timers, are reset except for PSM and eDRX timers, periodic HPPLMN search timer, inter-rat scan timer, T3396, T3346 and other backoff timers which are saved and restored at deep-sleep exit.

7.1.1   Deep-sleep and applications

Some embedded applications and features are aware of deep-sleep mode and can temporarily postpone the entrance into deep-sleep mode until all pending activities completed. Such activities are LwM2M, positioning and security. which may wait for server response. The AT interface is also deep-sleep aware. The AT interface deep-sleep aware client restarts a 12s guard timer any time a character is received or sent. Additional UART power savings can be enabled via the +UPSV AT command. Application-initiated deep-sleep prevention can be monitored via the +UUPSMR:2,<client_id> URC.

Other activities are not aware of deep-sleep mode and have no control over it. Deep-sleep un-aware applications include local connectivity features, e.g. PPP and MUX, and IP-based applications, e.g., MQTT, USOCK, UDNS, UFTP and HTTP They might be negatively impacted by the UE entering in deep-sleep:

- Only network registration data is kept, all other volatile application settings including open sockets are lost and need to be restored at deep-sleep exit;
- PPP and MUX are locally deactivated and need to be restored at deep-sleep exit;
- Deep-sleep can be entered during data sessions such as UDP, TCP or secure sockets.

For example, in case of PSM deep-sleep, the negative impact happens if the RRC connection is released and the T3324 expires while the UE is waiting for a network response. The network response delay can be a consequence of a temporary server outage or packet loss in low coverage or mobility. To mitigate deep-sleep negative impact:

- Transaction duration can be reduced by using UDP sockets instead of TCP ones, which also consumes less power,
- The host application can temporarily prevent deep-sleep entry by issuing the AT+UPSMVER=,,,,1 AT command: this allows to schedule retransmissions and to eventually end the transaction. Note that no data reception is possible when the network considers the device in deep-sleep, i.e. after the +UUPSMR: 2,6 URC is issued.

Like IP based applications, firmware download and asynchronous AT commands, like +UDWNFILE, have no control on deep-sleep. Deep-sleep temporary disablement via AT+UPSMVER=,,,,1 needs to be used to avoid deep-sleep entry during firmware download or while waiting for the async AT command response.

To postpone deep-sleep entry during a blocking AT command execution, AT commands can be issued on another virtual AT port. When possible, deep-sleep temporary preventing with AT+UPSMVER=,,,,1 is preferred to the disabling and re-enabling of deep-sleep via the +CPSMS AT command, which would waste power in two extra deregistration-registration cycles. AT+UPSMVER=,,,,0 restores the normal behavior.

7.1.2 Deep-sleep and network scans

Host application triggered (COPS=?, +UCFSCAN) and periodic network scans (HPPLMN and CIoT Inter-RAT), which can be monitored via the +USCANSTAT URC on SARA-R42 "01B" product version and LEXI-R422 modules, can postpone the deep-sleep entry. To keep power consumption low HPPLMN and CIoT Inter-RAT scans need to be avoided on static applications, or performed as rarely as possible, especially if NB-IoT RAT is enabled.

- The HPPLMN scan, performed when "automatic network selection" mode is enabled by the +COPS AT command and the module is registered on a roaming network (i.e., not a home network), can be disabled and configured via the AT+UHPPLMN AT command on SARA-R42 "01B" product version and LEXI-R422 modules or avoided via +CPOL settings.
- The CIoT Inter-RAT scan, performed when the UE is registered on the HPLMN and not the highest priority RAT, can be configured via the +URATSCAN AT command and disabled with the same AT command on LEXI-R422 modules or avoided via +URAT settings.

7.1.3 Deep-sleep indications

The host application can monitor the entrance and exit from deep-sleep state in several ways:

- GPIO "module status indication", see +UGPIOC AT command description in the AT command manual [1].
- **V_INT** monitoring.
- +UUPSMR URC, issued when entering and exiting deep-sleep mode.

7.1.4 Deep-sleep options

To recap, deep-sleep mode can be configured by the +CPSMS and +UPSMVER AT commands. Meaningful combinations are:

- `+CPSMS=0`: deep-sleep mode disabled (default setting).
- `+CPSMS=1, +UPSMVER=,,,,0`: deep-sleep mode enabled and deep-sleep entry possible.
- `+CPSMS=1, +UPSMVER=,,,,1`:deep-sleep mode prevented by the deep-sleep temporary disablement. The `+UUPSMR: 2,6` URC is issued when deep-sleep entry is prevented.

When deep-sleep mode is enabled, it can be configured in three options:

1. OOS deep-sleep, see section 7.1.5
2. PSM deep-sleep, see 3GPP PSM feature described in section 7.2
3. eDRX deep-sleep, see 3GPP PSM feature described in section 7.3

The 3GPP PSM feature legacy usage involves periodic PSM deep-sleep entry. However, the feature can be also used without periodically entering PSM deep-sleep when needed by a deep-sleep unaware application (see PSM deep-sleep example). The 3GPP eDRX feature legacy usage does not involve periodic eDRX deep-sleep entry, which can be enabled to increase power savings (see eDRX deep-sleep example).

3GPP PSM and eDRX features can be used separately or together. In the latest case PSM and eDRX legacy usage applies, periodically entering PSM deep-sleep unless temporarily disabling it, while it is not possible to also enable eDRX deep-sleep (see eDRX deep-sleep example). OOS deep-sleep can be used with the other two deep-sleep options (see OOS deep-sleep example in section 8.1.5).

The following examples illustrate PSM deep-sleep and eDRX deep-sleep options usage. They assume the module is network registered; for instance, LTE Cat-M1 network registration is taken.

PSM deep-sleep

Command	Response	Description
`AT+CLCK="SC",2`	`+CLCK: 0` `OK`	Verify if SIM PIN check is disabled, if not, disable it.
`AT+UPSMVER?`	`+UPSMVER: 4,3,3,4,0` `OK`	Verify default values are set in the +UPSMVER AT command: PSM deep-sleep option selected (<psm_ver>=4) and deep-sleep temporary disablement not set (<temp_dis>=0). If not, set default values.

`AT+CFUN=0`
`AT+CPSMS=1`
`AT+CSCON=1`
`AT+UPSMR=1`
`AT+CFUN=15`
	`OK`
	`OK`
	`OK`
	`OK`
	`OK`
		Enable deep-sleep as well as +UUPSMR and +CSCON URC.

`AT+CPSMS?`	`+CPSMS: 1,,,`
	`"00111000","00001010"`
	`OK`
		Read +CPSMS settings to see deep-sleep is enabled (<mode>=1) and, once PSM deep-sleep option selected by +UPSMVER, the 3GPP PSM feature request is enabled (PSM related timers are returned in the +CPSMS read response with non-null timer values).

`AT+UCPSMS?`	`+UCPSMS: 1,,,`
	`"00111000","00001010",1`
	`OK`
		Check if the 3GPP PSM feature usage request has been granted (<mode>=1 in the +UCPSMS read response): only in this case the 3GPP PSM feature is used.
		PSM deep-sleep can be periodically entered as per 3GPP PSM feature timers (+UUPSMR: 1,1 displayed at PSM deep-sleep entry).

`AT+UPSMVER=,,,,1`	`OK` `+UUPSMR: 2,6`	Temporarily disable deep-sleep when needed due to deep-sleep unaware applications usage. The 3GPP PSM feature is used but PSM deep-sleep mode is not entered.

eDRX deep-sleep

Command	Response	Description
`AT+CLCK="SC",2`	`+CLCK: 0` `OK`	Verify if SIM PIN check is disabled, if not, disable it.

Command	Response	Description
AT+UPSMVER?	+UPSMVER: 4,3,3,4,0 OK	Verify default values are set in the +UPSMVER AT command. If not, set default values.
AT+CPSMS?	+CPSMS: 0,,, "01100000","00000000" OK	Make sure default +CPSMS settings are set, if not, disable deep-sleep. Read +CPSMS settings to see deep-sleep is disabled (<mode>=0) and the 3GPP PSM feature request is disabled (PSM related timers are returned in the +CPSMS read response with null timer values despite non-null timer values are set).
AT+CSCON=1	OK	Enable +CSCON URCs.
AT+CEDRXS=2,4	OK	Enable the 3GPP eDRX feature request. Enable the +CEDRXP URC to report negotiated eDRX timer values (volatile).
AT+CEDRXS?	+CEDRXS: 4,"1011","0011" OK	Read +CEDRXS settings to see the 3GPP eDRX feature request is enabled (eDRX related timers are present in the +CEDRXS read response).
<wait_for_eDRX_negotiation>		If the UE is LTE Cat-M network-registered eDRX feature negotiation is performed. The example continues assuming the eDRX feature is granted (TeDRX and PTW assigned).
AT+CEDRXRDP	+CSCON: 1 +CEDRXP: 4,"1011","1011","0011" +CSCON: 0 +CEDRXRDP: 4,"1011","1011","0011" OK	Check if the 3GPP eDRX feature usage request has been granted (eDRX related timers are returned in the +CEDRXRDP response): only in this case the 3GPP eDRX feature is used. Being deep-sleep disabled eDRX deep-sleep is not periodically entered. Being 3GPP PSM feature disabled eDRX is used standalone (i.e., not in combination with PSM).
AT+CFUN=0 AT+CPSMS=1 AT+UPSMR=1 AT+CFUN=15	OK OK OK OK	Enable deep-sleep as well as +UUPSMR URC.
AT+CPSMS? AT+CEDRXS?	+CPSMS: 1,,, "00111000","00001010" OK +CEDRXS: 4, "1011","0011" OK	Read +CPSMS settings to see deep-sleep is enabled (<mode>=1) and, being PSM deep-sleep option selected by +UPSMVER, the 3GPP PSM feature request is enabled. Read +CEDRXS settings to see the 3GPP eDRX feature request is also enabled. There are 3 possible cases (please refer to sections 8.2.3 and 8.3.4 to check which one applies). • If only eDRX feature is granted, it is used standalone, without entering eDRX deep-sleep. • If only PSM feature is granted, PSM deep-sleep is periodically entered. • If both eDRX and PSM features are granted, eDRX is used in combination with PSM and PSM deep-sleep is periodically entered.
AT+UPSMVER=8 AT+CFUN=15	OK OK	Select eDRX deep-sleep option.
AT+CPSMS? AT+CEDRXS?	+CPSMS: 1,,, "01100000","00000000" OK +CEDRXS: 4,"1011","0011" OK	Read +CPSMS settings to see deep-sleep is enabled (<mode>=1) and the 3GPP PSM feature request is disabled. Read +CEDRXS settings to see the 3GPP eDRX feature request is enabled. If eDRX feature is granted, it is used standalone, periodically entering eDRX deep-sleep.
AT+UPSMVER=,,,,1	OK +UUPSMR: 2,6	Temporarily disable deep-sleep when needed due to deep-sleep non-aware applications usage.

7.1.5   Deep-sleep state in OOS

In prolonged OOS conditions, the module will continue to perform full PLMN scans until service is gained. OOS deep-sleep enables power saving in this case: after several unsuccessful network scans, which can be monitored via +USCANSTAT URC on SARA-R42 "01B" product version and LEXI-R422 modules, the module enters the power-efficient deep-sleep state for a certain period. Both the

number of scans performed in a row and the deep-sleep duration can be configured via the `+UPSMVER` AT command. The same AT command can disable the feature.

OOS deep-sleep

Command	Response	Description
`AT+UPSMVER?`	`+UPSMVER: 4,3,3,4,0` `OK`	Check default OOS deep-sleep configuration applies: OOS deep-sleep option selected (<oos_scans>), 3 full scans performed (<oos_scans>), 4 min of sleep (<deep_sleep_oos_dur>). If not, set it.

`AT+CFUN=0`
`AT+CPSMS=1`
`AT+UPSMR=1`
`AT+CFUN=15`
	`OK`
	`OK`
	`OK`
	`OK`
		Enable deep-sleep to also enable OOS deep-sleep option.

`AT+UPSMVER=,,0` `AT+CFUN=15`	`OK` `OK`	If needed, disable OOS deep-sleep option (<oos_scans>=0) keeping deep-sleep enabled: deep-sleep can be used in PSM deep-sleep and eDRX deep-sleep options.

7.2 Power Saving Mode (PSM)

PSM is a 3GPP standard feature that minimize power consumption for devices that require sporadic cellular network access. Instead of switching off the module at the end of the data transfer, if PSM is enabled with the `+CPSMS` AT command, a device can negotiate time periods up to 413 days, during which keepalive notifications can be postponed and the module can stay registered to the network. This allows devices to skip paging reception and enter the minimum functionality PSM deep-sleep mode.

PSM is relevant on LTE Cat-M and NB-IoT RATs. The host application is suggested to configure it before NW registration, settings apply to both RATs. The application-configured requested PSM settings are NVM persistent and used at any registration procedure, periodic or due to mobility in other areas. The requested PSM settings can be configured via the `+CPSMS` AT command, whereas the PSM settings assigned by the network, which are the used one, can be discovered via the `+CEREG` URC and the `+UCPSMS` AT command. If PSM is not granted by the network, the module cannot use PSM. If so, in case of long inactivity periods, the host application could power on and off the module when needed.

Two timers determine the entrance into PSM deep-sleep mode. Both timers start when the NW releases an existing RRC connection, and are reset if a new RRC connection is established before timer expiry. RRC connection setup and release can be monitored via the `+CSCON` URC.

- T3324, the active timer, the shorter one. At T3324 expiry, the module stops monitoring paging and thus can enter the PSM deep-sleep mode as soon as it has completed any pending activity. If the NW needs to send any MT data, e.g. MT trigger, then it always pages the UE before the active timer expiry. If the NW does not allow the UE to use PSM feature, it does not assign the active timer.
- T3412, the periodic Tracking Area Update(TAU) timer, the longer one. At T3412 expiry, the module exits PSM deep-sleep, if PSM is used, and performs a TAU procedure. The T3412 timer value can be legacy or extended. By default, the cellular network sets the T3412 duration to 54 minutes, while the extended timer duration can be up to 413 days long.

7.2.1 PSM and applications

After active timer expiry, when deep-sleep is scheduled, pending mobile terminated (MT) traffic indications, such as SMS or small data packets, are likely to be stored while large MT data packets are likely to be discarded at the network side.

To send any pending MT traffic from the application server (AS) to the application client (AC), applications are suggested to implement a pull mechanism:

- The AS can send a small MT trigger (SMS or small data packet). The trigger is NW-buffered and delivered to the AC at UE PSM exit.
- Upon trigger reception the AC sends a mobile originated (MO) pull message to the AS.
- Upon pull message reception the AS completes the MT data delivery. Optional MO acknowledgement can follow.

7.2.2 Configuration recommendations

The selection of the requested T3412 timer value is a trade-off between power consumption and the tolerated MT data delay, which is the limit factor for the T3412 timer duration

The selection of the requested T3324 timer value is a trade-off between power consumption and responsiveness. Low values save more battery life making it possible for the UE to enter PSM deep-sleep mode more quickly. High values of T3324 give some margin to the application server (AS) to respond to MO data sent by the UE before it enters PSM. AS responses to MO data can be both MO data acknowledgements as well as MT data delivery as a response to MO pull messages. As a rule of thumb, the maximum suggested T3324 is 10 times shorter than T3412 and vice-versa. The minimum suggested T3324 should allow reliable paging and needs to be tuned because it depends on:

- The time when the network releases an existing RRC connection, signaled by the `+CSCON` URC,
- Any temporary service loss, signaled by the `+CEREG` URC,
- The number of needed retransmissions related to the Coverage Extension (CE) mode currently assigned to the UE, which can be read via the `+CEINFO` AT command,
- Whether the network uses discontinuous reception (DRX), which can be read via the `+UCGED` AT command; at least 2 DRX cycles are needed,
- Whether the network uses extended discontinuous reception (eDRX), which can be read via the `+CEDRXRDP` AT command, at least 2 eDRX cycles are needed,
- Possible retransmissions or buffer time of data at network side, e.g. 10s.

If MT data or acknowledgements are not considered in the application design, power can be minimized requesting the longest possible 413 days T3412 timer duration and the shortest possible 0 s T3324 timer duration.

Customers are advised to check with MNOs above parameters as well as the MT data buffering policy, the APN idle time and SMS expiry timer and to test both parameters to come to a value that best fits their use case and requirements regarding power consumption, MT data delay, and reliability.

7.2.3 Timer values

7.2.3.1 Encoding of timer T3412

The extended TAU timer is encoded as GPRS timer 3 IE (see TS 3GPP TS 24.008 [16]).

Bits 5 to 1 represent the binary coded timer value. Bits 6 to 8 define the timer value unit for the GPRS timer and are encoded as follows.

```
BIT    8 7 6
       0 0 0 value is incremented in multiples of 10 minutes
       0 0 1 value is incremented in multiples of 1 hour
       0 1 0 value is incremented in multiples of 10 hours
       0 1 1 value is incremented in multiples of 2 seconds
       1 0 0 value is incremented in multiples of 30 seconds
       1 0 1 value is incremented in multiples of 1 minute
       1 1 0 value is incremented in multiples of 320 hours
```

For example: "**010**00111" = 7 **x 10 hours** = 70 hours

If the network does not grant an extended periodic TAU timer value, the standard periodic TAU timer value can be decoded using the T3324 timer table, as they share the same encoding. The standard or extended value encoding of the periodic TAU timer is indicated by the <Assigned_Periodic_TAU_Format_Type> parameter of the +UCPSMS AT command response.

7.2.3.2 Encoding of timer T3324

The Active Time T3324 is encoded as GPRS timer IE (see TS 3GPP TS 24.008 [16]).

Bits 5 to 1 represent the binary coded timer value. Bits 6 to 8 define the timer value unit for the GPRS timer as follows:

```
BIT    8 7 6
       0 0 0 value is incremented in multiples of 2 seconds
       0 0 1 value is incremented in multiples of 1 minute
       0 1 0 value is incremented in multiples of decihours (6 minutes)
```

For example: "**000**00100" = 4 **x 2 s** = 8 s

7.2.4 Example of PSM configuration

This example illustrates how the 3GPP PSM feature, disabled by default, can be configured and how to check NW assigned settings.

Command	Response	Description
AT+CLCK="SC",2	+CLCK: 0 OK	Verify if SIM PIN check is disabled, if not, disable it.
AT+CEDRXS?	+CEDRXS: OK	Verify if eDRX is disabled, if not, disable it.
AT+UPSMVER?	+UPSMVER:4,3,3,4,0 OK	Verify default values, with PSM deep-sleep option selected, are set in the +UPSMVER AT command. If not, set default values.
AT+CSCON=1 AT+UPSMR=1	OK OK	Enable +CSCON and +UUPSMR URCs.
AT+CFUN=0 AT+CPSMS=1,,,"00111000" ,"00001010" AT+CFUN=15	OK OK OK	Enable the 3GPP PSM feature requests. Set PSM timer values (T3412(ext)=24 hours and T3324=20 s in the example) suitable to the host application.
AT+CPSMS?	+CPSMS:1,,,"00111000","00001010" OK	Read +CPSMS settings to see deep-sleep is enabled (<mode>=1) and the 3GPP PSM feature is requested at each NW registration with selected timer values.
AT+CEREG=4	OK	Enable the +CEREG extended syntax to report NW registration and PSM feature negotiation status. Note this setting is volatile.

Command	Response	Description
`<wait_for_NW_registrati on>`		During successful network registration PSM feature negotiation is performed. Read the <stat> and <Assigned_Active_Time> parameters in the +CEREG AT command response and the <mode> and <Assigned_Active_Time> parameters in the +UCPSMS AT command response to check which of the following 3 cases applies.

`AT+CEREG?`
 `AT+UCPSMS?`
	`+CSCON: 1`
	 `+CEREG: 1,"1","0","1",7`
	 `,,,"00001010","00111001`
	 `"`
	
	 `+CEREG: 4,1,"1","0","1",`
	 `7,,,"00001010","00111001`
	 `"`
	 `OK`
	 `+UCPSMS: 1,,,`
	 `"00111001","00001010",1`
	 `OK`
		Case 1:
		 • the UE successfully registers to network,
		 • the PSM feature is granted (T3324 assigned).
		
		 Check the assigned PSM timer values displayed both in +CEREG and +UCPSMS AT command response: in this example T3324=20 s and T3412(ext)=25h. As it can be seen from +UCPSMS <Assigned_Periodic_TAU_Format_Type>, in this example T3412(ext) timer value comes with extended duration, thus it is displayed both by +CEREG and +UCPSMS.

`AT+CEREG?`
 `AT+UCPSMS?`
	`+CSCON: 1`
	 `+CEREG: 1,"1","0","1",7`
	 `,,,,`
	
	 `+CEREG: 4,1,"1","0","1",`
	 `7,,,,`
	 `OK`
	 `+UCPSMS: 0,,,`
	 `"01001001",,0`
	 `OK`
		Case 2:
		 • the UE successfully registers to network,
		 • the PSM feature is not granted (T3324 not assigned).
		
		 Check the assigned T3412 timer value: in this example T3412=54 min. As it can be seen from +UCPSMS <Assigned_Periodic_TAU_Format_Type>, in this example T3412 timer value comes with legacy duration, thus it is only displayed by +UCPSMS.

`AT+CEREG?`
 `AT+UCPSMS?`
	`+CEREG: 0`
	
	 `+CEREG: 4,0`
	 `OK`
	 `+UCPSMS: 0`
	 `OK`
		Case 3:
		 • the UE does not successfully register to network,
		 • the PSM feature cannot be granted.

`<wait_for_RRC_connectio n_release>`		The example continues assuming Case 1 has been observed.
	`+CSCON: 0`	Monitor the +CSCON URC to get the time instant the NW releases an existing RRC connection and both T3324 and T3412 timers start running. T3324 and T3412 timers are set with the NW-assigned values which may be different from the UE-requested values.

	`+UUPSMR: 1,1`
	 or
	 `+UUPSMR: 2,3`
	 `+UUPSMR: 1,1`
		Monitor the +UUPSMR URC or any other deep-sleep indication described in section 8.1.3 to see when the UE enters deep-sleep.
		 After T3324 expiry, the UE may enter PSM deep-sleep directly or with a delay (+UUPSMR <state>=2). In the latest case the UE enters deep-sleep as soon as it has completed any pending activity or deep-sleep temporary prevention (+UPSMVER <temp_dis>) is switched-off, if set.

	`+UUPSMR: 0`	Monitor the +UUPSMR URC or any other deep-sleep indication described in section 8.1.3 to see when the UE exits deep-sleep. The UE may exit PSM deep-sleep by itself, e.g. at T3412 expiry to perform a TAU. The PSM deep-sleep mode exit can be also anticipated by the host application through an early wake-up via the PWR_ON pin if needed.
`ATD*99***1#` `AT+CEREG=4`	`CONNECT` `OK`	After deep-sleep exit, re-enable volatile URCs, locally restore PPP mode if needed. IP address will be the same assigned during attach, and uplink data can be sent to the network without the need to re-register.

7.3 Extended Discontinuous Reception (eDRX)

LEXI-R422 / SARA-R42 series modules support the 3GPP Release 13 feature Extended Discontinuous Reception (eDRX). When using eDRX, the UE in RRC idle (+CSCON: 0) listens to paging only periodically, without losing any paging indication, to save power. Paging is listened to only during short time periods called paging time windows (PTW), uniformly disposed in time for different UEs,and ignored the rest of time. There is one PTW per eDRX cycle. eDRX is relevant on LTE Cat-M and NB-IoT RATs. The application can enable eDRX feature negotiation via the +CEDRXS AT command separately for each RAT. The command also allows configuration of eDRX parameters: the requested eDRX cycle duration, also called TeDRX, and the PTW duration. If the network grants eDRX usage the assigned and finally used eDRX values can be read via +CEDRXP URC and +CEDRXRDP AT command.

eDRX is encouraged in applications where MT traffic is considered in the application design and a MT data delivery delay is affordable. It is suggested to deliver MT data with a pull mechanism already described for PSM. As a rule of thumb, eDRX is preferred to PSM when the maximum admissible MT data delay is shorter than the network T3412 duration, which has a default value of 54 minutes. In this case, to minimize power consumption, it is suggested to set the requested TeDRX cycle duration equal to the maximum affordable MT data delivery delay, and to set the requested PTW to the minimum duration, which makes paging reception reliable; same rules as the one described for PSM apply. Customers are advised to test out both TeDRX and PTW parameters to come to a value that best fits their use case and requirements in terms of power consumption, MT data delay and reliability.

eDRX can be also used along with the PSM feature. In this case eDRX is used while the T3324 timer is running, as shown in Figure 5Figure 5. When the UE tries to negotiate both PSM and eDRX features, the network interprets the request as following; if the requested TeDRX and T3412 extended values have similar durations then the network interprets that the UE would like to use eDRX or PSM, if the requested TeDRX cycle is at least one order of magnitude smaller than the requested T3412 extended value then the network interprets that the UE would like to use eDRX during the T3324 active time.
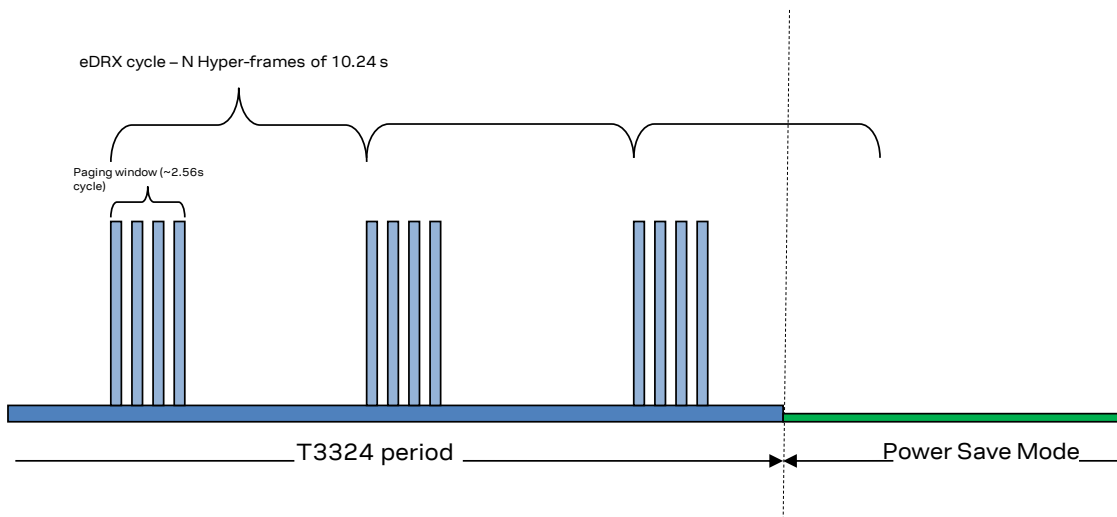
Figure 5: Paging listening when DRX, eDRX and PSM are enabled.

7.3.1.1 Encoding of timer TeDRX

The TeDRX length, i.e. the requested eDRX cycle duration, is encoded as per Table 10.5.5.32/3GPP TS 24.008 [16]:

```
0 0 0 0      5.12 seconds
0 0 0 1      10.24 seconds
0 0 1 0      20.48 seconds
0 0 1 1      40.96 seconds
```

```
0 1 0 0      61.44 seconds
0 1 0 1      81.92 seconds
0 1 1 0      102.4 seconds
0 1 1 1      122.88 seconds
1 0 0 0      143.36 seconds
1 0 0 1      163.84 seconds
1 0 1 0      327.68 seconds
1 0 1 1      655.36 seconds
1 1 0 0      1310.72 seconds
1 1 0 1      2621.44 seconds
1 1 1 0      5242.88 seconds
1 1 1 1      10485.76 seconds
```

☞ In LTE Cat M1 for the eDRX cycle length duration of 5.12 s the eDRX cycle parameter 'TeDRX' is not used.

☞ The 0000 and 0001 are only applicable in LTE Cat M1. If received in NB-IoT they need to be interpreted as if eDRX has not been granted by the network.

☞ The 0100, 0110, 0111 and 1000 values are only applicable in LTE Cat M1. If received in NB-IoT they need to be interpreted as the 0010 value.

☞ The 1110 and 1111 values are only applicable in NB-IoT. If received in LTE Cat M1 they need to be interpreted as the 1101 value.

7.3.1.2 Encoding of timer PTW

The PTW length is encoded as per Table 10.5.5.32/3GPP TS 24.008 [16]:

```
LTE Cat-M1                          NB-IoT
0 0 0 0      1.28 s                 0 0 0 0      2.56 s
0 0 0 1      2.56 s                 0 0 0 1      5.12 s
0 0 1 0      3.84 s                 0 0 1 0      7.68 s
0 0 1 1      5.12 s                 0 0 1 1      10.24 s
0 1 0 0      6.4 s                  0 1 0 0      12.8 s
0 1 0 1      7.68 s                 0 1 0 1      15.36 s
0 1 1 0      8.96 s                 0 1 1 0      17.92 s
0 1 1 1      10.24 s                0 1 1 1      20.48 s
1 0 0 0      11.52 s                1 0 0 0      23.04 s
1 0 0 1      12.8 s                 1 0 0 1      25.6 s
1 0 1 0      14.08 s                1 0 1 0      28.16 s
1 0 1 1      15.36 s                1 0 1 1      30.72 s
1 1 0 0      16.64 s                1 1 0 0      33.28 s
1 1 0 1      17.92 s                1 1 0 1      35.84 s
1 1 1 0      19.20 s                1 1 1 0      38.4 s
1 1 1 1      20.48 s                1 1 1 1      40.96 s
```

7.3.2 eDRX deep-sleep and paging only image

When the affordable MT data delivery delay is longer than 10 minutes, it is possible for the module to further minimize its power consumption by entering deep-sleep mode when not listening to paging, i.e. when not in the PTW periods. This feature can be enabled as usual with AT+CPSMS=1 command, after having selected eDRX deep-sleep option with AT+UPSMVER=8 command, which forces eDRX to be used standalone, disabling PSM requests to the network.

When the eDRX deep-sleep feature is used, a low power module FW called POI (Paging Only Image) is loaded during periodic PTW periods. POI loading is enabled by default and can be disabled with the AT+UPSMVER=8,0 AT command. When POI is loaded, the module is unresponsive until it changes status by itself, due to deep-sleep mode exit at periodic TAU, paging reception or early wake-up (which is effective only once the module has entered the deep-sleep state after the PTW period). Transitions between eDRX deep-sleep mode and POI can be monitored via the RXD or DSR UART lines, which become high during POI period, whereas the module status indication GPIO, V_INT RXD levels (see section 7.1.3) do not change with respect to eDRX deep-sleep state. Usage of POI in eDRX is notified with +UUPSMR: 1,2 URC when entering eDRX deep-sleep mode from normal operation.

7.3.3 Functional diagram of eDRX and PSM

For sake of clarity, Figure 6 illustrates the states transitions and device activity when both PSM and eDRX are active. Some configurable parameters are highlighted in the figure. In this case the negotiated eDRX cycle duration is TeDRX=10.24 s. During the PTW, the module listens to paging continuously or discontinuously in case the network uses discontinuous reception. In below example the network uses discontinuous reception with a discontinuous reception cycle TDRX=2.56 s. It should be noticed that unlike PSM related timers, eDRX and DRX related ones start instant does not depend on any previous RRC connection release. The negotiated T3324 and T3412 timers are also highlighted: eDRX is used during the T3324 active time.

1. The device is in PSM deep-sleep state, not responsive to AT commands nor paging messages. It has already registered at startup, negotiating PSM timers.
2. PSM is exited at early wake-up triggered by the host application or at T3412 timeout.
3. In case of an early wake-up the host application is expected to start a MO transmission. If a T3412 timeout occurs, the device sends a TAU keepalive message, performing a new PSM and eDRX negotiation. The device re-connects to the network.
4. Once the data or control packet transmission or reception is complete, the RRC connection is released by the network. The device enters the idle state and starts T3324 and T3412 timers.

5. While the T3324 timer is running, paging is listened to as per eDRX and DRX configuration.

6. PSM is entered after T3324 has elapsed. Operations continue as per point 1.

If after point 2 the device does not enter RRC connected state, the device will eventually re-enter PSM state as if it had not awakened from it.
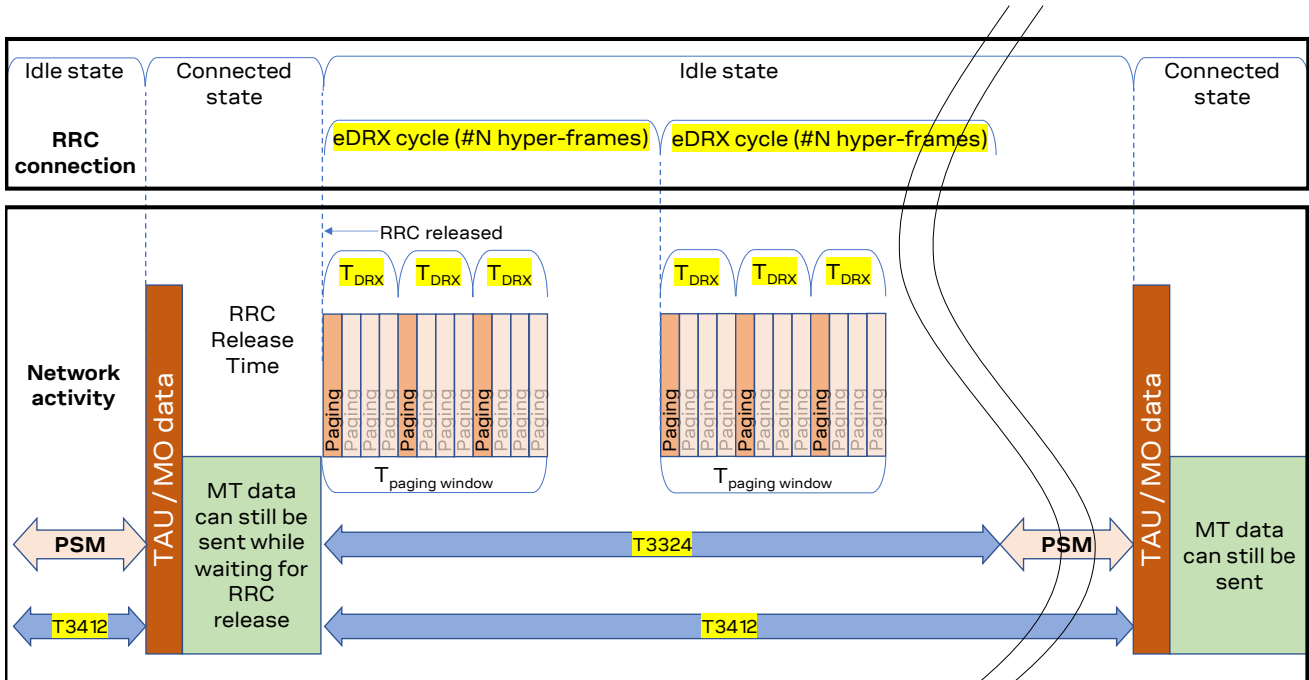
Figure 6: State transitions and module activity when both PSM and eDRX are enabled

7.3.4 Example of eDRX configuration

This example illustrates how the 3GPP eDRX feature, disabled by default, can be configured and how to check NW assigned settings.

Command	Response	Description
AT+CLCK="SC",2	+CLCK: 0 OK	Verify if SIM PIN check is disabled, if not, disable it.
AT+CPSMS?	+CPSMS: 0,,, "01100000","00000000" OK	Verify if PSM is disabled, if not, disable it.
AT+UPSMVER?	+UPSMVER:4,3,3,4,0 OK	Verify if the +UPSMVER AT command is set to its default value, if not, select it.
AT+CSCON=1 AT+UPSMR=1	OK OK	Enable +CSCON and +UUPSMR URCs.
AT+CEREG=4	OK	Enable the +CEREG URC to report NW registration status (volatile).
AT+CEDRXS=2,4, "0111","0111"	OK	Enable the 3GPP eDRX feature requests. Set eDRX timer values (TeDRX=~2min, PTW=~10s in the example) suitable to the host application. Enable the +CEDRXP URC to report negotiated eDRX timer values (volatile).

Command	Response	Description
`<wait_for_ eDRX_negotiation>`		If the UE is LTE Cat-M network-registered eDRX feature negotiation is performed. The example continues assuming the eDRX feature is granted (TeDRX and PTW assigned).

`AT+CEDRXRDP`
`AT+CEREG?`
`AT+UCPSMS?`
	`+CSCON: 1`
	`+CEDRXP: 4,`
	`"0111","0111","0011"`
	`+CEDRXRDP: 4,`
	`"0111","1010","0111"`
	`+CEREG: 4,1,"1","0","1",`
	`7,,,,`
	`OK`
	`+UCPSMS: 0,,,`
	`"01001001",,0`
	`OK`
		Check the assigned and finally used eDRX timer values, if any, displayed both in +CEDRXP URC and and +CEDRXRDP AT command response: in this example (TeDRX=~2min and PTW=~5s in this case). Also check the +UCPSMS response to get the assigned T3412 timer.

	`+CSCON: 0`	Monitor the +CSCON URC to get the time instant the NW releases an existing RRC connection and the eDRX feature starts being used.

`AT+CFUN=0`
`AT+CPSMS=1`
`AT+UPSMVER=8,0`
`AT+CFUN=15`
		Enable eDRX deep-sleep for additional power savings.
		Monitor the +UUPSMR URC or any other deep-sleep indication described in section 8.1.3 to see when the UE enters and exits deep-sleep.

`AT+CFUN=0`
`AT+UPSMVER=8,3`
`AT+CFUN=15`
		Enable eDRX deep-sleep with POI loading during PTW to further increase power savings.
		Monitor POI loading using in any of the ways described in section 8.3.2.

`ATD*99***1#` `AT+CEREG=4;+CEDRXS=2,4`	`CONNECT` `OK`	After deep-sleep exit, re-enable volatile URCs, locally restore PPP mode if needed. IP address will be the same assigned during attach, and uplink data can be sent to the network without the need to re-register.

8   Monitoring module status

8.1   Retrieve and interpret diagnostic information

It is recommended to track the module status in the host application. Such diagnostic information allows detection of specific scenarios and implementation of proper handling and countermeasures in the host application.

The module status can be returned by AT command responses and unsolicited result codes (URCs). Depending on the host application architecture, URCs, periodic polling, or both, can be used. URCs provide the most updated information and, in some cases, diagnostic information which is not available via polling. For AT commands that enable URCs, they might also return the same information when polled.

Some commands store the setting of the URC reporting in the non-volatile memory (NVM), so they are called persistent settings.

Some AT commands provide a choice on how to handle the URCs when the AT interface is busy; for all other AT commands, URC is issued at the return into command mode, as explained in the AT command manual [1], in the "URCs presentation deferring" section.

URCs and AT command responses are presented with their generic syntax as parameters names are explanatory. For their precise meanings, see the AT command manual [1].

8.1.1 Diagnostic information via URCs

Command	URC	Description	Can be polled
AT+CSCON=1	+CSCON: 1	Return the status of the RRC connection (idle or connected). Persistent setting.	Yes
AT+CREG=3	+CREG: <stat>[,[<lac>],[<ci>][,[<AcTStatus>][,<cause_type>,<reject_cause>]]]	Enable registration status URC for non-EPS services (for example, SMS) and reject cause in case of unavailability of such services.	Yes
AT+CEREG=5	+CEREG: <stat>[,[<tac>],[<ci>],[<AcT>][,[<cause_type>],[<reject_cause>][,[<Assigned_Active_Time>,[<Assigned_Periodic_TAU>]]]]]	Enable registration status URC for EPS services, reject cause in case of unavailability of such services and PSM related timers if granted by the network.	Yes
AT+CGREG=2	+CGREG: <stat>[,<lac>,<ci>[,<AcT>,<rac>]]	Enable registration status URC for PS services in 2G networks.	Yes
AT+USCANSTAT=1	+USCANSTAT: <scan_state>, <scan_type>,<scanned_act>[, <scanned_act>[,<scanned_act>]]	Enables the current band scan status, type and device radio technology reporting. After enabling the URC reporting, the +USCANSTAT URC is issued to return the current band scan status and band scan type along with its radio technology information: thereafter, if either the parameter <scan_state> or <scan_type> changes, a +USCANSTAT URC will be issued.	Yes
AT+CGEREP=2,1	+CGEV: NW PDN DEACT <cid>	Report all registration and PDN connectivity status events. The first parameter of the AT command is set to 2 indicate that URC will not be discarded in case the AT interface is busy.	No
AT+CTZR=1	+CTZV: <tz>	Enable reporting of changes in time zone. Usually, time zone information is provided by the network at LTE attach only.	No
AT+CMER=1,0,0,2,1	+CIEV: <descr>,<value>	Report variations in some indicators like roaming, SIM indication (provided that the feature is configured via +UGPIOC), signal level.	No
AT+CNMI=2,1	+CMTI: <mem>,<index>	Report the index in current selected memory (can be the factory-programmed setting ME or SIM, see +CPSM read command) where the mobile terminated SMS has been stored. The first parameter set to 2 indicates that URC are buffered in case of busy AT interface. The setting is volatile and shall be re-entered at every switch on or exit from PSM.	No
AT+USIMSTAT=7	+UUSIMSTAT: <state>	Report SIM initialization progress, SIM phonebook initialization progress, and SIM REFRESH events (each group of URCs can be singularly disabled). SIM Refresh URC might indicate the change of some operational parameters in the UICC card (for example, IMSI swap, SIM profile installation after remote SIM provisioning). The setting is persistent.	No
AT+UBIP=1	+UUBIP: <ev_cmd>,<val>	URC are raised when Open Channel, Close Channel, Send Data, Receive Data and Channel status events are issued by the SIM card towards the device to handle a SIM OTA session, for example for remote SIM provisioning. The embedded BIP client will cater for establishing the required socket and exchange data with the SIM OTA server. The setting is persistent.	No

Command	URC	Description	Can be polled
`AT+UFOTASTAT=1`	`+UFOTASTAT: <event>,<param1>[,<param2>]`	Provide information on the progress and outcome of the Firmware download over the air via LwM2M (uFOTA). The setting is persistent.	No
`AT+ULWM2MSTAT=1`	`+ULWM2MSTAT: <event>,<param1>[,<param2>]`	Enable URC to report the activity of the embedded LwM2M client. The setting is persistent.	No
`AT+CEINFO=1`	`+CEINFO: <reporting>,<CE_enabled>,<UE_state>,<downlink_repetition_factor>,<uplink_repetition_factor>,<RSRP_value>,<CINR>`	Volatile setting, it reports variation of the Coverage extension mode and related transmission parameters (for example, repetitions schemes to be used) detected by the device or assigned by the network.	Yes
`AT+CEDRXS=1`	`+CEDRXP: <AcT_type>[,<Requested_eDRX_cycle>[,<Assigned_eDRX_cycle>[,<Assigned_paging_time_window>]]]`	If eDRX is used by the host application, the URC can report changes in eDRX settings imposed by the network in different areas or times. The setting is persistent.	Yes

☞ Always consider to apply the `+CGEREP` AT command with <mode> equal 2, for example `AT+CGEREP=2`, in order to avoid to lose URCs when the AT interface is busy in executing some other AT commands.

8.1.2   Diagnostic information via polling

Command	Response (omitting OK)	Description	Suggested usage
`ATI` `ATI9`	`SARA-R422M8S-00B-00` `00.12,A00.00`	Return the model and FW identification, useful for tracking purposes.	Module initialization
`AT+CGSN`	`355438110017558`	Return the IMEI.	Module initialization
`AT+CIMI` `AT+CCID`	`001010123456789` `+CCID: 89860000502000180722`	Return the SIM identities for tracking purposes. They can change after a SIM refresh event that can be reported by +UUSIMSTAT URC.	Module initialization
`AT+UBANDMASK?`	`+UBANDMASK: 0,185079967,2,1,134748319,1048642,2,2621824`	Return band mask selection.	Module initialization
`AT+UMNOPROF?`	`+UMNOPROF: 90`	Return MNO profile set.	Module initialization
`AT+UCGED?`	`+UCGED: 2` `6,<svc>,<MCC>,<MNC><EARFCN>,<Lband>,<ul_BW>,<dl_BW>,<TAC>,<LcellId>,<P-CID>,<mTmsi>,<mmeGrId>,<mmeCode>,<RSRP>,<RSRQ>,<Lsinr>,<Lrrc>,<RI>,<CQI>,<avg_rsrp>,<totalPuschPwr>,<avgPucchPwr>,<drx>,<l2w>,<volte_mode>[,<meas_gap>,<tti_bundling>`	Return several cell parameters as measured by the module or provided by the network. Some values like CQI and signal indicators are periodically refreshed in the module on a 0.5 s base, so the application should average them.	Low periodicity
`AT+CESQ?`	`+CESQ:,,,,<rsrq>,<rsrp>`	Return signal quality and level, and it is more precise than +CSQ. It is subjected to transitions due to local reset of values at	Periodically (for example, every 50 to 10 s)

Command	Response (omitting OK)	Description	Suggested usage
		changes in RRC state (idle, connected) so the host application should average the values.	
AT+COPS?	+COPS: <mode>[,<format>,<oper>[,<AcT>]]	It returns the current registered PLMN in the configured format, RAT is fixed to 7 (LTE, Cat-M1).	Periodically (30 s) and when detecting problems
AT+CGATT?	+CGATT: 0	As AT+COPS?, it returns 0 when the module enters in out of coverage conditions, despite no PS detach has occurred and PS services are just suspended.	Periodically (20 s) and when detecting problems
AT+CGDCONT?	+CGDCONT: <cid>,<PDP_type>,<APN>,<PDP_addr>,<d_comp>,<h_comp>[,<IPv4AddrAlloc>,<request_type>,<P-CSCF_discovery>,<IM_CN_Signalling_Flag_Ind>[,<NSLPI>[,<secure_PCO>[,<IPv4_MTU_discovery>[,<Local_Addr_Ind>]]]]]	It returns the active and defined EPS bearers with the APN used and the IP type and addresses.	Periodically (30 s) and when detecting problems
AT+CPOL?	+CPOL: <index1>,<format>,<oper1>[,<GSM_AcT1>,<GSM_Compact_AcT1>,<UTRAN_AcT1>[,<E-UTRAN_AcT>]]	It returns the high priority PLMN list, which might change at SIM refresh.	Module initialization and SIM refresh, only in debug/test mode
AT+CEDRXRDP	+CEDRXRDP: <AcT_type>[,<Requested_eDRX_cycle>,<Assigned_eDRX_cycle_value>,<Assigned_paging_time_window>]	It returns the current eDRX parameters assigned by the mobile network.	If eDRX is used, the host should monitor CTS line to avoid waking up the module during eDRX/sleep periods
AT+CPSMS?	+CPSMS: <mode>,[<Requested_Periodic_RAU>],[<Requested_GPRS_READY_timer>],[<Requested_Periodic_TAU>],[<Requested_Active_Time>]	It returns the PSM settings as required to the network. As setting is persistent, if the network does not grant PSM, the module will propose the PSM timers at every attach and registration attempt.	Module initialization
AT+UCPSMS?	+UCPSMS: <mode>,[<Assigned_Periodic_RAU>],[<Assigned_GPRS_READY_timer>],[<Assigned_Periodic_TAU>],[<Assigned_Active_Time>],[<Assigned_Periodic_TAU_Format_Type>]	It returns the PSM settings as assigned by the network. If PSM timers are not reported by +CEREG, this command can be periodically polled. Periodic TAU timer is also reported.	At change of registration information (as reported by +CEREG)

☞ To check the detected radio signal strength and quality, see the +CESQ AT command for LTE networks (Cat M1 and NB-IoT), and the +CSQ AT command for 2G networks (GSM/EGPRS).

8.2 Full-stack watchdog: how to react to unexpected conditions

The application shall properly handle communication or connectivity problems that can arise when using the module in the cellular mobile environment.

When a problem at a specific level is encountered, the countermeasure for that level should be tried and, if not resolving the issue, proceed with the solutions for the lower levels. Table 14 shows a full-stack watchdog for monitoring SARA-R42 and LEXI-R422 series modules.

Level	Problem	Countermeasure	AT commands / actions	Notes
Socket/dial-up	Cannot send/receive data	Close and re-open socket	`AT+USOCL=<socket_id>` `AT+USOCR=<protocol>` `AT+USOCO=…`	
		Disconnect and re-connect dial-up	Send `+++` / Move DTR `ATD*99***<cid>#`	
IP/PDP	Cannot get an IP address; cannot establish dial-up	Detach/re-attach	`AT+CFUN=0` `AT+CFUN=1`	Consider restrictions to multiple <cid>s active for APN. If IPv6-only PDN is set in Verizon Wireless MNO setting, detach/deactivation may be caused by failing IPv6 acquire by SLAAC. The retry is managed automatically based on VZW DR logic. Automatic deactivation does not apply if UL data is disabled via +UMNOPROF: 9,0.
		Deactivate/re-activate context (<cid> != 1)	`AT+CGACT=0,<cid>` `AT+CGACT=1,<cid>`	
Network registration	Cannot register	Detach/re-attach	`AT+CFUN=0` `AT+CFUN=1`	Preferably use AT+CFUN=0/1 for registration cycles. AT+CFUN=0/1 is faster than AT+COPS=2/0.
RF	Cannot register	Disable/re-enable RF functionality	`AT+CFUN=0` `AT+CFUN=1`	AT+CFUN=4 is NVM persistent, better to use AT+CFUN=0.
Module FW	Cannot register	Soft reset	`AT+CFUN=15`	
AT interface	No response from module	HW switch off	GPIO power control	For details and alternatives, see the corresponding series system integration manual [4][5].

Table 14: Full-stack watchdog for SARA-R42 and LEXI-R422 series modules

9 SIM

9.1 SIM communication

Modem and SIM card communicate through a serial interface. The modem automatically starts a communication with the SIM at boot for cellular protocol stack operations. The host application can interact with applets and services residing in the SIM card using a set of AT commands. Based on capabilities these commands can be divided in two groups:

- Commands for restricted access
- Commands for generic access

9.1.1 Commands for restricted access

Commands for restricted access are a set of high-level commands that allow simple but limited interactions with the SIM and its contents. The handling of all the steps required by communication protocol used by modem - SIM interface is managed internally by the modem, and therefore not a concern for the host application.

This subset includes the `+CRSM` and `+CRLA` AT commands.

9.1.1.1 Examples of UICC communication

Below are examples of commands for restricted access.

Command	Response	Description
Read IMSI(International Mobile Subscriber Identity)		
`AT+CRSM=176,28423,0,0,0`	`+CRSM: 144,0,"082922107840836055"` `OK`	Read the IMSI. 176 is the read command for EF in binary format. 28423 is the ID for EF_IMSI, the SIM elementary file where IMSI is stored by SIM manufacturer. The <response> parameter in +CRSM answer contains few prefix bytes followed by the IMSI value with swapped nibbles.
`AT+CIMI`	`222018704380655` `OK`	Read the IMSI. The response is the readable serial number. This example is for reference only, as an alternative AT command to read IMSI.
LOCI management		
`AT+CRSM=176,28542,0,0,0`	`+CRSM: 144,0,"623C50A322F210D5BD0000"` `OK`	Read EF_LOCI, the SIM elementary file where information about last CS location is stored
`AT+CRSM=214,28542,0,0,11,"FFFFFFFFFFFFFFFFFFFFFF"`	`+CRSM: 144,0,""` `OK`	Erase EF_LOCI content. This command is useful to start a registration procedure from scratch. For this purpose, erase the below EF too: • EF_PSLOCI (28531) • EF_EPSLOCI (28643)
Read emergency call Codes		

`AT+CRSM=178,28599,1,4,0`	`+CRSM: 144,0,"11F2FFFFFFFFFFFFFFFF`
	`FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF`
	`FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF`
	`FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF`
	`FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF`
	`FFFFFFFFF"`
		Read the list of emergency call numbers stored in the SIM by MNO.
		178 is the read command for EF in record format.

Command	Response	Description
	OK	

9.1.2 Commands for generic access

Commands for generic access are a subset of low-level commands that allow the direct control of messages sent to and received from the SIM. The full knowledge of APDU protocol syntax and procedures is therefore needed.

This subset includes the `+CSIM` and `+CGLA` AT commands.

9.1.3 SIM logical channels

The exchange of messages (APDU) between SIM card and modem occurs through "logical channels" that work on the physical SIM serial interface.

9.1.3.1 Basic logical channel

At modem boot, the "basic logical channel" (logical channel 0) is automatically opened, and it is used for cellular protocol stack operations.

This channel is owned by the module, and the host application is not allowed to close it. For the same reason, internal module commands have the priority, and AT commands that do not coordinate (e.g., `+CSIM`) will not disrupt the module functionality but might be disturbed by the module.

9.1.3.2 Supplementary logical channels

To allow interactions with applets and services residing in the SIM card, cellular SIM cards supports supplementary logical channels (up to 3).

These channels shall be explicitly activated by the module, and the SIM card assigns them a progressive number from 1 to 3. The user or host application can manage logical channels using proper AT commands. It is recommended to use an independent supplementary channel for each different applet/service and to close them at the end for reuse.

In SARA-R42 and LEXI-R422 modules, in addition to logical channels 0, the module automatically activates logical channel 1, which can be use by the host application. Since some SIM applications (e.g., ISD-R) cannot have multiple sessions, they should be selected on the channel intended for them and in these cases the usage of logical channel 1 could be mandatory.

Command	Response	Description
Generic SIM access		
`AT+CSIM=10,"0070000000"`	`+CSIM: 6,"029000"` OK	Open a new supplementary logical channel. As per ISO/IEC 7816-4, <response> parameter contains • the number assigned to the opened channel: "02". (i.e., channel "01" is already active) • the action result: "9000" ('Command successfully executed')
`AT+CSIM=10,"0170800200"`	`+CSIM: 4,"9000"` OK	Close the supplementary channel 2 (indicated in the 4th byte), using supplementary ch1 (indicated in the 1st byte). SARA-R4 and LEXI-R422 allow commands for supplementary channel closure only if received on channel 0 or 1.

9.2 Chip SIM

For devices using a soldered-down chip SIM, consider what network or networks the device will connect to. Furthermore, consider the need to connect to a test network or base station simulator call-boxes, which may require a specific UICC profile. Anticipate such needs and configure a profile to connect to such networks or simulators.

Below are some alternatives for testing purposes:

- Configure a device with a SIM card holder for physical removable SIM for such engineering or pre-production activities.
- Disable authentication and integrity checks on the tester side by proper setting, and on the module by using the `AT+UDCONF=81,0` AT command.

10 SMS

10.1 Preferred message storage

The factory-programmed value for LEXI-R422 / SARA-R42 series modules is "ME" for the three memory parameters <mem1>, <mem2> and <mem3>. The setting can be set or read by the +CPMS AT command.

The example below sets all memory parameters to "ME" by the +CPMS AT command.

Command	Response	Description
AT+CPMS="ME","ME","ME"	+CPMS: 0,23,0,23,0,23 OK	Set all three memory storage parameters to "ME" memory storage.
AT+CPMS?	+CPMS: "ME",0,23,"ME",0,23,"ME",0,23 OK	Read the storage setting.

10.2 SMS handling and access technology

All MNO profiles use combined attach (CS & PS). If successful, both data and SMS services are allowed. If LTE attach is successful for EPS only services, SMS can still be supported (the "SMS only" case). If LTE attach is not successful for SMS, the module can try registration on a different RAT, e.g., 2G. Accordingly, the SMS support could be related to the selected access technology.

If AT+URAT=8 is applied, the attach becomes "EPS only" (with "SMS only" additional update type included). In this case, even if SMS services are accepted, the +CREG read command and URC would report that it is not registered for CS services.

Since it is possible that SMS services are not supported in NB-IoT, in AT+URAT=8 there is no means to understand this other trying to send out an SMS. In addition, because the network is not including SMS only flag in the attach accept message, the module will repeat tracking area update (TAU) about every 10 s, causing high power consumption. In summary:

1. In mono-RAT (NB-IoT), i.e. AT+URAT=8, registered on a network without SMS support:

   o TAU procedures every 10 s for maximum 5 times every 12 minutes (around 25 times per hour).
   o Pay attention to power consumption.

2. In multi-RAT (NB-IoT plus LTE Cat M1 and/or 2G), e.g. AT+URAT=7,8,9, registered on a network without SMS support:

   o Standard TAU procedures.
   o longer network scans (the NB-IoT is the RAT with longest scans).
   o This configuration could be considered as a possible trade-off.

3. In multi-RAT (NB-IoT plus LTE Cat M1 and/or 2G), e.g. AT+URAT=7,8,9 registered on a network with SMS support:

   o +CREG indication is reliable in 2G RAT.
   o +CREG indication is not reliable in LTE Cat M1/NB-IoT, accordingly try to send a SMS.
   o +CSCON indication reports information about the radio connection status.

In conclusion, working in a multi-RAT configuration is recommended, and considered as a possible workaround to the scenarios described above in point 1 and 2.

10.3 SMS auto-ACK

It is possible to configure manual acknowledgement of MT SMS (RP-ACK) via AT+CSMS=1, AT+CNMI=1,2 and AT+CNMA commands. To fully enable this feature, the LwM2M client must be disabled by issuing

the `AT+ULWM2M=1` command. Note that the setting is persistent across power cycles and that the disabling of the LwM2M client will prevent uFOTA feature.

11 EFS backup & restore

Due to the nature of Flash memory, the Embedded File System (EFS) may incur memory corruption if the safe & graceful shutdown procedure outlined in the corresponding system integration manual [4] [5] is not followed. It is possible that memory corruption may result in the device being inoperable or impact specific device data information.

For a fatal memory corruption, the EFS backup & restore feature allows the module to autonomously restore the EFS using the last EFS backup stored on the module itself.

Backup of device's unique parameters (like for example RF calibration data, IMEI, etc.) is performed at the u-blox factory and is stored on the module as the first backup copy for the device. The host application has the option to make subsequent backups to supersede the previous backup copy. If an EFS corruption is detected, then the restore is triggered autonomously at the device boot-up process to restore the device with the single backup copy stored on the device.

Backup & Restore is a unique feature that may extend the lifetime of the modules in the field.

⚠️ It is critical that the host application follows the proper safe & graceful shutdown procedure outlined in the system integration manual [4] [5]. The backup & restore feature is intended only as an additional backup mechanism if, on the potential rare occasion, the host application shutdown is not conforming to the graceful power down guidelines.

11.1 Description

There are two parts to the EFS backup & restore feature for SARA-R42 / LEXI-R422 series modules.

The backup feature is optional for a device that comes with this feature from the factory, where the host can perform a backup of the file system to supersede the previous or original backup done during the module production. This will allow the latest user values in the file system to be captured in the backup copy. The procedure could include security data, e.g., certificates.

The restore function allows the modules to automatically recover from a fatal file system corruption if it detects such a corruption from previous improper shutdown at the next module boot-up. If the corruption is non-fatal, where the module can boot up, then the host can manually trigger a restore.

There are three types of non-fatal corruptions:

- Loss of IMEI
- MNO profiles lost or duplicated
- Device goes into the non-signaling mode (for more details, see the Production and validation test app note listed in Table 1)

☞ Only in one of the above conditions should a restore be host triggered.

☞ Personalization data for security, calibrations and unique data will be restored. User files, parameters and profiles will be handled by the backup and restore process differently, based on the SARA-R42 product series implementations, as shown in the Table 15.

Item	SARA-R42 "00B" product version	SARA-R42 "01B" product version and LEXI-R422 modules
Personalization data for security, calibrations, and unique data	Restored.	Restored.
Files in user file system	Not considered by the backup and restore process.	Not considered by the backup and restore process.
MNO profiles	Back to the factory programmed settings (i.e. MNO profile 90 "Global" as default). After backup & restore	Restored, if previously backed-up.

Item	SARA-R42 "00B" product version	SARA-R42 "01B" product version and LEXI-R422 modules
	process, select desired MNO profile with +UMNOPROF.	
User NVM settings (i.e. +UBANDMASK)	Back to the factory programmed settings.	Restored, if previously backed-up.
User certificate and private keys	Back to the factory programmed settings if any.	Restored, if previously backed-up.

Table 15: Backup & restore feature implementation

11.1.1 EFS backup

The EFS backup can be initiated with the `+UBKUPDATA` AT command and will automatically trigger a backup process upon receiving the command. After this procedure is completed, the device stores status information that can be queried with an AT command, no further action is required.

Optionally, the host can issue backup on an infrequent and rare basis according to the demand. This could be when some significant information in the file system has been modified via AT commands. For example, information regarding the personalization data for security. One scenario is after the host application factory initial "production", which may include the module configuration of a specific use case requirement related to the security functionalities. Creating a backup in this "production" scenario is likely safe, as long as the production is handing the module in a safe manner that does not expose risk to memory corruption before performing the backup. The backup command can also provide some information about the last backup.

The command's query response contains the number of backups and restores for each file system.

⚠️ To avoid excessive flash wear, the backup should be performed on a limited basis, such as after host application production and initialization.

☞ There are not multiple backup "versions" stored: only a single copy of the latest backup is kept.

☞ It can take up to 15 s to execute a backup.

To detect that the backup function is completed, and the AT interface is available:

- Wait for `+UUBKUPDATA` URC
  - Example URC of a successful backup: `+UUBKUPDATA: 1,1`

11.1.2 EFS restore

When an automatic restore is triggered, the device will immediately reset/restore the file system (this may interrupt any running processes). The device will then reset, and store status information that can be queried with an AT command. After the restore procedure is completed, no further action is required, although some settings may need to be restored manually by the user, if they were modified since the last backup.

If the restore process is interrupted (e.g. through power pull), the process will start from the beginning again at the next module boot-up.

There is no indication to the host processor that a restore is taking place during boot-up; it would just appear as a longer-than-usual boot-up. If a restore takes place, the host processor shall allow more time for the device to handle the restore, until the AT interface is available.

☞ It can take up to 15 s for a restore to execute. This time includes the boot-up time.

The host can detect when a restore has taken place by a URC notification, e.g., the `+UUBKUPDATA: 2,1` URC indicates the restore has taken place and is successful.

☞ After sending the +UUBKUPDATA: 2,1 URC, a reboot is automatically performed by the module.

A manual restore can be triggered when one of the following conditions is detected by the host:

- Loss of IMEI, which can be detected with the +CGSN AT command, where:
  o +CSGN returns the "+CME ERROR: memory failure" error result code
- MNO profiles lost or duplicated, which can be detected with +UMNOPROF AT command
- The device goes into the non-signaling mode and is unable to exit with AT+UTEST=0, and +CFUN cannot change its state from a value of 5. This non-signaling state can be checked with the +CFUN read command, where the device would return a value of 5.

Restore is only intended for the above situations.

Example of +CGSN AT command to detect lost IMEI

Command	Response	Description
AT+CGSN	+CME ERROR: memory failure	Error result code indicates lost IMEI using +CGSN AT command.

To detect it the module boot-up is complete and AT interface is available after a possible restore:

- Loop AT, e.g., every one second, until the "OK" final result code is received.
- Enable and monitor the GPIO pins with "Module status indication" function by the +UGPIOC AT command.
- Enable and monitor the greeting message via the +CGST AT command.
  Both the module status indication and greeting message option would require to be enabled and then saved into the EFS backup copy. If a restore should ever be triggered, then the EFS backup copy would be restored with the feature enabled.

11.1.3 Creating backup after flashing FW update with delta package

If a FW with the backup & restore feature is updated via FOTA / uFOTA with a delta package, then after the successful update a restore is triggered autonomously by the module.

11.1.4 EasyFlash, backup and SMS storage

If a FW with the backup & restore feature is flashed onto a module via EasyFlash, after a successful FW update, when the device boots up, the host is required to:

- Define a new EFS backup through the +UBKUPDATA AT command.
- Set the preferred SMS message storage, if different from the factory-programmed setting, with +CPMS AT command just once after flashing. This step is required if the host application use SMS, otherwise this step can be ignored.

11.1.5 Secure storage backup & restore

The secure storage is used to persist security critical data. The secure storage backup/restore functionality is used when the secure storage is corrupted because of an EFS corruption.

To monitor the secure storage corruption, use the following AT commands:

Command	Response	Description
AT+USECROTUID	+CME ERROR: SEC RoT not personalized	Error result code indicates secure storage corruption.

In case of secure storage corruption, execute the following AT commands:

Command	Response	Description
AT+USECOPCMD="rotrestore",1	OK	Restore the secure storage.

Command	Response	Description
AT+CFUN=15	OK	Reset the device to execute the restore operation.
AT+USECOPCMD="rotresync"	OK	Resync the status of the secure storage.
AT+CFUN=15	OK	Reset the device to execute the resync operation.

12 Restore factory configuration

During operation with the module, different files may be stored in the module's file system. Similarly, the NVM is populated with user configuration as well as auxiliary information stored by the module to optimize its operations (e.g. information on the cellular environment).

⚠ To avoid excessive flash wear, the factory configuration restoration must be performed on a limited basis.

☞ LEXI-R422 / SARA-R42 series modules present a unique profile which can be restored with the ATZ command.

☞ See AT commands factory-programmed values stored in NVM and profiles appendix of the AT commands manual [1].

The host application can restore the module factory configuration via the +UFACTORY AT command. This can be required to recover from an unexpected behavior and restart the module in a controlled configuration, or during the MNO certifications, where the device is tested in various simulated scenarios and the auxiliary information or previous user settings can affect the tests outcome.

Restoring the factory configuration takes 2 steps:

1. Set the type of restore, using the +UFACTORY AT command. FS and/or NVM can be restored.
2. Reboot the module.

The +UFACTORY AT command writes a flag in NVM and does not perform any restoring action. This flag is then read at the next reboot, when the +UFACTORY corresponding action is executed. Therefore, it is possible to cancel the +UFACTORY action by issuing the AT+UFACTORY=0,0 command before the reboot.

Table 16 shows some examples.

Command	Response	Description
Delete all user files previously saved with USER flag in the file system		
AT+UFACTORY=1,0	OK	Set +UFACTORY to delete all user files previously stored with USER flag in the file system. No restore is performed so far.
AT+UFACTORY?	+UFACTORY: 1,0 OK	Check the restore action currently set.
AT+CFUN=16	OK	Reboot the module. At next reboot, the restore action previously set is applied.
Delete all modem profiles in NVM		
AT+UFACTORY=0,1	OK	Set +UFACTORY to delete all modem profiles. In detail: native modem profiles are reset, while added modem profiles are deleted. No restore is performed so far.
AT+UFACTORY?	+UFACTORY: 0,1 OK	Check the restore action currently set.
AT+CFUN=16	OK	Reboot the module. At next reboot, modem profiles are reverted to the factory programmed values.
Restore UART and UPSV settings to default in NVM		
AT+UFACTORY=0,2	OK	Set +UFACTORY to restore UART and +UPSV settings to default in NVM. No restore is performed so far.
AT+UFACTORY?	+UFACTORY: 0,2 OK	Check the restore action currently set.

Command	Response	Description
AT+CFUN=16	OK	Reboot the module. At next reboot, UART and +UPSV settings are reverted to the factory programmed values.
Cancel a delete operation (before reboot)		
AT+UFACTORY=1,0	OK	Set a +UFACTORY action.
AT+UFACTORY?	+UFACTORY: 1,0 OK	Check the action currently set. Now, a user files deletion is requested and will be applied at next reboot.
AT+UFACTORY=0,0	OK	Cancel any delete action.
AT+UFACTORY?	+UFACTORY: 0,0 OK	No delete action will be applied at next reboot.

Table 16: +UFACTORY AT command examples

☞ After having issued a +UFACTORY AT command with <nvm_op>=1, it is required a second reboot to make the module again ready to properly accept and store new settings to NVM.

12.1 Module echo handling

The command echo E has its own configuration and it is important for the implementation of the AT commands parser. It controls whether or not the DCE echoes characters received from the DTE during command state.

The storing of this parameter depends on the product version and series, as shown in Table 17. In legacy products, it is necessary to apply the AT&W command for storing the echo setting.

Command E	SARA-R42 "01B" product versions and LEXI-R422	SARA-R42 "00B" product versions
Setting stored in NVM	**yes (persistent)**	**no (volatile)**
Factory default (AT Commands Manual)	on	
Module shipped (actual production default)	off	
	Before user's EFS Backup procedure by AT+UBKUPDATA	
EFS Restore (AT+UBKUPDATA)	off (set in production by ATE0 before the EFS Backup procedure)	
EasyFlash	on	
Restore factory configuration (AT+UFACTORY)	on	
	After user's EFS Backup procedure by AT+UBKUPDATA	
EFS Restore (AT+UBKUPDATA)	Off, or as set by the user before the latest EFS Backup by command E	
EasyFlash	on	
Restore factory configuration (AT+UFACTORY)	on	

Table 17: Command echo E configuration

☞ In SARA-R42 "01B" product version and LEXI-R422 modules, the command echo E is persistent. Users shall avoid referring to it as an indication of possible module reboots, e.g., SW resets. For this specific purpose, it is advisable to use other volatile AT commands or the greeting text by the +CSGT AT command.

13 u-blox services handling

SARA-R42 series modules are built with some u-blox services, i.e. internal IP applications, e.g., LwM2M client, security services, etc… User side tuning could be needed to properly interact with the u-blox services.

For more details about u-blox services, see the documents listed in the Table 1.

13.1 Interaction with private networks

When a LEXI-R422 or a SARA-R42 series module is located inside a private network, e.g. a network with a private APN and its specific firewall rules, some configurations could be needed to properly manage the u-blox services.

The scenarios below are possible when a LEXI-R422 or a SARA-R42 series module are located in a private network:

1. The user is interested in u-blox services:
   o The private network must be properly set, e.g., routing tables, permissions, etc., so that the module can reach the u-blox reference servers for the running services (LwM2M, security, etc.)
2. The user is not interested in u-blox services:
   o Clients of u-blox services which are not in scope shall be properly and explicitly disabled:
      ▪ To disable LwM2M service: apply `AT+ULWM2M=1` then `AT+CFUN=16` (module reboot for saving NVM settings). For more details, see LwM2M objects and commands application note [12].
      ▪ To disable security service: apply `AT+CFUN=0` and `AT+USECMODE=0` then `AT+CFUN=16` (module reboot for saving NVM settings). This AT commands sequence could be issued if the SARA-R42 module is still in the `+USECDEVINFO: 1,0,1` status and the security sealing has not been performed.

☞ On SARA-R422M10S-01B-01 and SARA-R422S-01B-01 modules, the security client is disabled by default.

☞ On SARA-R422M10S-01B-02, SARA-R422S-01B-02 and LEXI-R422 modules, the security suite features are not supported.

14 Migration guide from SARA-R410M / SARA-R412M and hints

Below is a list of software changes between SARA-R410M / SARA-R412M and SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422 modules with a brief description, which could help in migrating a host application between the two modules. For detailed explanation of the AT commands mentioned, see the AT commands manual [1].

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
RATs	• 3GPP Rel. 14 LTE Cat M1 • NB2 • EGPRS	• 3GPP Rel. 13 LTE Cat M1 • NB1 • EGPRS	• 3GPP Rel. 13 LTE Cat M1 • NB1 (not supported by "63B" and "73B" product versions)	• 3GPP Rel. 13 LTE Cat M1 • NB1
Connected Mode Mobility (CMM)	Handover Intra-band & Inter-band	n.a.	Handover Intra-band	n.a.
USB enumeration	• HS-USB Diagnostics 90B2	• HS-USB Modem 90B2 • HS-USB Diagnostics 90B2 • HS-USB WWAN Adapter 90B2	• HS-USB Modem 90B2 • HS-USB Diagnostics 90B2 • HS-USB WWAN Adapter 90B2	• HS-USB Modem 90B2 • HS-USB Diagnostics 90B2 • HS-USB WWAN Adapter 90B2
AT interface	AT commands handler applies the proper line termination sequence "\r\n" to all supported AT commands.	AT commands handler applies the uncorrected line termination sequence "\n\r" in the +CSGT URC and some AT commands in test mode like "AT+UPSV=?", "AT+UFOTA=?" plus some others related to the LWM2M functionality.	AT commands handler applies the uncorrected line termination sequence "\n\r" in the +CSGT URC and some AT commands in test mode like "AT+UPSV=?", "AT+UFOTA=?" plus some others related to the LWM2M functionality.	AT commands handler applies the uncorrected line termination sequence "\n\r" in the +CSGT URC and some AT commands in test mode like "AT+UPSV=?", "AT+UFOTA=?" plus some others related to the LWM2M functionality.
Command echo E	• SARA-R42 "00B" product version: setting not stored • SARA-R42 "01B" product version and LEXI-R422: setting stored in NVM (persistent)	Setting available in module profile	Setting available in module profile	Setting available in module profile
AT commands and SIM PIN (1): &C &D &S A H S6	• SARA-R42: AT commands blocked by SIM PIN • LEXI-R42: AT commands not blocked by SIM PIN	AT commands blocked by SIM PIN,	AT commands blocked by SIM PIN,	AT commands blocked by SIM PIN,

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
S7 S8 S10 S2 +GCAP +WS46 +CEINFO +URPM +CSQ +COPS +CLAC +CVMOD +CPLS +CUAD +CEDRXRDP +CSCS +CRC +CGCONTRDP +CGSMS +CSAS +CVHU +CSODCP +CRTDCP				
AT commands and SIM PIN (2): +UMNOPROF +UBANDMASK +CUSATA +USOCLCFG +UJAD +UMQTTC	• SARA-R42: AT commands not blocked by SIM PIN • LEXI-R42: AT commands blocked by SIM PIN	AT commands not blocked by SIM PIN,	AT commands not blocked by SIM PIN,	AT commands not blocked by SIM PIN,
+USIO	Serial interfaces configuration options: • 0: AT="UART" and module tracing on USB • 1: AT="UART"; AT="AUX UART"	n.a.	n.a.	n.a.

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
	• 2: AT="UART" and module tracing on AUX UART • 4: AT="UART"; GNSS="AUX UART"[2] Available options: • SARA-R42 "00B" and SARA-R42 "01B-00": 0, 1, 4 SARA-R42 "01B-01", "01B-02" and LEXI-R42: 0, 1, 2, 4			
+UUARTCONF	Available for AUX UART configuration	n.a.	n.a.	n.a.
+CFUN (options)	0, 1, 4, 5, 15, 16, 19 Available options: • SARA-R42: 0, 1, 4, 5, 15, 16, 19 • LEXI-R42: 0, 1, 4, 5, 11, 15, 16, 19	0, 1, 4, 5, 15	0, 1, 4, 5, 15	0, 1, 4, 5, 15
+UMNOPROF	• Default MNO profile: 90 (global) • MNO profile 0 (undefined): n.a. • To restore the settings to the factory programmed values for the specific profile, the profile can be reapplied with UMNOPROF set command. Available options: • SARA-R42 "00B":	• Default MNO profile: 0 (undefined) • To restore the settings to the factory programmed values for the specific profile, the profile shall be changed via +UMNOPROF set command and set back to the current value. Available options: • SARA-R412M "02B": 0, 1, 2, 19, 31, 33, 44, 45, 46, 100, 101, 198	• Default MNO profile: 28 (Softbank) on "63B", 39 (SKT) on "73B", 4 (Telstra) on "83B" • To restore the settings to the factory programmed values for the specific profile, the profile shall be changed via +UMNOPROF set command and set back to the current value. Available options: • SARA-R410M "63B": 0, 1, 20, 28, 102	• Default MNO profile: 0 (undefined) • To restore the settings to the factory programmed values for the specific profile, the profile shall be changed via +UMNOPROF set command and set back to the current value. Available options: • SARA-R410M "02B":

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[2] Not supported by SARA-R422

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
	1, 19, 31, 46, 90, 100, 201 • SARA-R42 "01B": 2, 3, 19, 31, 46, 90, 100, 201, 206 • LEXI-R42: 19, 31, 46, 90, 100, 201		• SARA-R410M "73B": 0, 1, 38, 39 • SARA-R410M "83B": 0, 1, 4, 100, 101	0, 1, 2, 3, 4, 8, 19, 21, 31, 33, 43, 44, 45, 46, 100, 101, 198, 206
+UMNOPROF: 100 (Standard Europe)	Enabled bands: • SARA-R42 "00B": B3, B8, B20 • SARA-R42 "01B-00": B3, B8, B20 SARA-R42 "01B-01", "01B-02" and LEXI-R42: B1, B3, B8, B20	Enabled bands: • B3, B8, B20	n.a.	Enabled bands: • B3, B8, B20
+UBANDMASK (options)	(0-2),18446744073709551615, 18446744073709551615	(0-1), 0xffffffffffffffff,0xffffffffffffffff	(0-1), 0xffffffffffffffff,0xffffffffffffffff	(0-1), 0xffffffffffffffff,0xffffffffffffffff
+URAT (options)	7, 8, 9	7, 8, 9	7, 8[3]	7, 8
<AcT> support in: +COPS +CREG +CGREG	0, 3, 7, 9	0, 3, 7, 9	7, 9	7, 9
+COPS	<mode>=0 (automatic) in set functionality does not reset the selected RATs configuration	<mode>=0 (automatic) in set functionality does reset the selected RATs configuration	<mode>=0 (automatic) in set functionality does reset the selected RATs configuration	<mode>=0 (automatic) in set functionality does reset the selected RATs configuration
+CGACT	Always issue the AT+CGACT=1,<cid> command on used context <cid> even if the +CGDCONT AT command returns that the context is still active with a valid IP address. This is highly recommended to activate the PS data connection avoiding possible conflicts between applications.	Optional	Optional	Optional

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[3] Not supported by SARA-R410M-63B and SARA-R410M-73B product versions

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
+USOWR (timeout in OOS conditions)	• SARA-R42 "00B": o 11 secs for not secure sockets o 11 secs for secure sockets • SARA-R42 "01B" and LEXI-R42: o 11 secs for not secure sockets o 1 secs for secure sockets	• 11 secs for not secure sockets • 11 secs for secure sockets	• 11 secs for not secure sockets • 11 secs for secure sockets	• 11 secs for not secure sockets • 11 secs for secure sockets
+CTZU (options)	• SARA-R42 "00B" default value: 0: automatic time zone via NITZ disabled • SARA-R42 "01B" and LEXI-R422 default value: 1: automatic time zone via NITZ enabled	0: automatic time zone via NITZ disabled	0: automatic time zone via NITZ disabled	0: automatic time zone via NITZ disabled
+UHPPLMN	• SARA-R42 "00B": n.a. • SARA-R42 "01B" and LEXI-R42: o available for setting the periodic search for higher priority PLMN (HPPLMN)	n.a.	n.a.	n.a.
+USCANSTAT	• SARA-R42 "00B" and SARA-R42 "01B-00": n.a. • SARA-R42 "01B-01", "01B-02" and LEXI-R42: o available for checking the network band scan status	n.a.	n.a.	n.a.
+URATSCAN	• SARA-R42 "00B", "01B-00" and "01B-01": o effective only when registered on the HPLMN	n.a.	n.a.	n.a.

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
	• SARA-R42 "01B-02" and LEXI-R42: o effective also in roaming			
+UURCCONF	• SARA-R42 "00B": n.a. • SARA-R42 "01B" and LEXI-R42: o available for configuring the list of the AT terminals enabled for URC reception	n.a.	n.a.	n.a.
+UPSV (options)	0, 3, 4	0, 4	0, 4	0, 4
+UPSMVER (options)	4, 8	1, 2, 4, 8	1, 2, 4, 8	1, 2, 4, 8
+UCGED (options)	0, 2 The option 5 is considered as a redundant syntax: accordingly it has been dropped.	0, 2, 5	0, 2, 5	0, 2, 5
SMS URCs with MUX	Available	n.a.	n.a.	n.a.
ePCO disabling	+UCFGCIOT AT command	Suitable MNO profile 101	Suitable MNO profile 101 in SARA-R410M-83B only	Suitable MNO profile 101
+ULWM2M	• SARA-R42 "00B": the LwM2M client is enabled by default • SARA-R42 "01B" and LEXI-R42: the LwM2M client is enabled by default only for the Verizon MNO profile	The LwM2M client is enabled by default.	The LwM2M client is enabled by default.	The LwM2M client is enabled by default.
+ULWM2MSTAT URC	Applied syntax (no spaces between the provided values) +ULWM2MSTAT: <event>,<param1>[,<param2>]	Applied syntax (spaces between the provided values) +ULWM2MSTAT: <event>, <param1>[, <param2>]	Applied syntax (spaces between the provided values) +ULWM2MSTAT: <event>, <param1>[, <param2>]	Applied syntax (spaces between the provided values) +ULWM2MSTAT: <event>, <param1>[, <param2>]
+UFOTASTAT URC	Applied syntax (no spaces between the provided values) +UFOTASTAT: <event>,<param1>[,<param2>]	Applied syntax (spaces between the provided values) +UFOTASTAT: <event>, <param1>[, <param2>]	Applied syntax (spaces between the provided values) +FOTASTAT: <event>, <param1>[, <param2>]	Applied syntax (spaces between the provided values) +UFOTASTAT: <event>, <param1>[, <param2>]

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
+UFTPC	FW update through FTP, resume a previously suspended session by the <fw_download_status> parameter: AT+UFTPC=100,"SARA-R42.upd",0	FW update through FTP, cancel a running session by the <fw_download_status> parameter: AT+UFTPC=100,"SARA-R41.upd",0	FW update through FTP, cancel a running session by the <fw_download_status> parameter: AT+UFTPC=100,"SARA-R41.upd",0	FW update through FTP, cancel a running session by the <fw_download_status> parameter: AT+UFTPC=100,"SARA-R41.upd",0
+UPSMR and related +UUPSMR URC	Applied syntax (no spaces between the provided values) +UUPSMR: <state>[,<param1>]	Applied syntax (spaces between the provided values) +UUPSMR: <state>[,<param1>]	Applied syntax (spaces between the provided values) +UUPSMR: <state>[,<param1>]	Applied syntax (spaces between the provided values) +UUPSMR: <state>[,<param1>]
+UBKUPDATA	- SARA-R42 "00B": - module unique data restored - user files, parameters and profiles (customer settings), not restored - SARA-R42 "01B" and LEXI-R42: - module unique data restored - user files not restored - MNO profiles, user NVM settings, user certificate, and private keys are restored, if previously backed-up	- module unique data restored - the whole file system (customer settings too) restored	n.a.	- module unique data restored - the whole file system (customer settings too) restored
+UFACTORY	available	n.a.	n.a.	n.a.
+UGPIOC <gpio_id> supported values (more details about in the official AT Commands Manual)	Available options for <gpio_id>: - SARA-R42 "00B": 7, 16, 23, 24, 25, 42, 19 - SARA-R42 "01B": 7, 16, 23, 24, 25, 42, 19, 34, 35 - LEXI-R42: 10, 14, 15, 16, 17, 29, 18, 44, 45	Available options for <gpio_id>: 7, 16, 23, 24, 25, 42, 19	Available options for <gpio_id>: 7, 16, 23, 24, 25, 42, 19	Available options for <gpio_id>: 7, 16, 23, 24, 25, 42, 19

Command or feature	SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S / LEXI-R422	SARA-R412M-02B-03 SARA-R412M-02B-04	SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	SARA-R410M-02B-03 SARA-R410M-02B-04
Security services[4], i.e.: • AT+USECMODE in SARA-R42 and LEXI-R422 • AT+USECOFF in SARA-R410M-x3B series	• SARA-R42 "00B" and SARA-R42 "01B-00": the security services are enabled by default • SARA-R42 "01B-01": the security services are disabled by default • SARA-R42 "01B-02" and LEXI-R42: the security services are not supported	n.a.	The security services are enabled by default.	n.a.
Internal GNSS	available[5]	n.a.	n.a.	n.a.
CellLocate®	available[6]	available	available	available

Table 18: Software migration guide from SARA-R412M and SARA-R410M

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[4] Not supported by SARA-R422, SARA-R412M and SARA-R410M-02B

[5] Not supported by SARA-R422, SARA-R422S and LEXI-R422

[6] Not supported by SARA-R422

Appendix

A Glossary

Abbreviation	Definition
CHAP	Challenge handshake authentication protocol
DCE	Data Circuit-terminating Equipment* / Data Communication Equipment*
DL	Down Link (Reception)
DRX	Discontinuous Reception
DTE	Data Terminal Equipment
eDRX	Extended DRX
FW	Firmware
HW	Hardware
LPWAN	Low Power Wide Area Network
LwM2M	Lightweight M2M
MNO	Mobile Network Operator
MO	Mobile Originated
MT	Mobile Terminated
NVM	Non-Volatile Memory
NW	Network
OPLMN	Operator Public Land Mobile Network
PAP	Password authentication protocol
PLMN	Public Land Mobile Network
PPP	Point-to-Point Protocol
PSM	Power Saving Mode
RAT	Radio access technology
RPLMN	Registered Public Land Mobile Network
SW	Software
TAU	Tracking Area Update
UE	User Equipment
URC	Unsolicited Result Code

B Cellular technology overview

SARA-R42 and LEXI-R422 modules support LTE Cat M1 and NB-IoT as LPWAN technologies, with 2G RAT fallback, making them ideal for a wide range of applications including:

- Automotive and transportation
- Smart metering
- Smart cities
- Smart buildings
- Connected health
- Agricultural and environmental

B.1 LTE Cat M1

LTE Cat M1 is a low-power wide-area (LPWA) air interface that enables the connection to IoT and M2M devices with medium data rate requirements. It increases battery lifespans thanks to enhanced power saving mode and extended in-building range (up to 15 dBm more than LTE, thanks to the repetitions of transmissions provided in the Coverage Enhancement modes), as compared to standard cellular technologies such as 2G, 3G, or LTE Cat 1.

LTE Cat M1 is defined by the 3GPP Release 13 and is a LPWA technology operating in the licensed spectrum. Operating in half duplex mode with typical speeds of 375 kbit/s, which can reach 1 Mbit/s on some networks thanks to protocol stack enhancements, LTE Cat M1 specifically supports IoT applications with low to medium data rate needs. At these speeds, LTE Cat M1 can deliver remote firmware updates over-the-air (uFOTA, with access to MNOs and u-blox servers via the LwM2M protocol) within reasonable timeframes, making it well-suited for critical applications running on devices that may be deployed in the field for extended periods of time.

The LTE Cat M1 standard specifies Connected Mode Mobility, which the module supports through inter-frequency and intra-frequency handover capability, resulting in higher reliability of transmissions, particularly important in non-static usage.

B.2 NB-IoT

Narrowband IoT (NB-IoT Internet of Things) is a Low Power Wide Area (LPWA) technology standardized by 3GPP release 13 as a specialization of the LTE standard, operating with 200 kHz bandwidth which allows it to work virtually anywhere. Since it operates in licensed spectrum, it is secure and reliable, providing guaranteed quality of service.

NB-IoT is optimized for applications that need to communicate small amounts of data over long periods of time. Like Cat M1, it offers very low power consumption and excellent extended coverage in buildings and underground. Battery life of up to 10 years on a single charge in some use cases also contributes to lower maintenance costs for deployed devices, even in locations where end devices may not be connected directly to the power grid.

LEXI-R422 / SARA-R42 series modules support both CP (Control Plane) and UP (User Plane) Cellular IoT EPS optimizations, Cat-NB2 (3GPP Release 14 upgraded version of the NB-IoT standard, which increases the maximum bit rate from ca 30-60 kbit/s to up to 120-160 kbit/s), NAS and AS (Access Stratum) RAI (Release Assistance Indicator) for faster release of the RRC connection at the end of the data transactions.

B.3 GSM/EGPRS

To assure global coverage, the module supports also 2G legacy RAT. It supports EGPRS class 33 with a downlink maximum speed of ~ 290 kbit/s (the peak bit rate depends on the quality of the radio link).

Being a data-only device, in 2G RAT, besides performing GPRS attach, the module also registers for CS (Circuit Switched) services to enable the GSM SMS service. This is a major difference compared to NB-IoT RAT, where often the SMS service is granted even if the LTE attach is accepted for EPS services only, thanks to the "SMS only" option negotiated during the LTE attach. Another major difference is that the host application needs to activate a PDP context to get an IP address and to use the module's IP based applications.

B.4 Low power profile features

When integrating LEXI-R422 / SARA-R42 series modules in a low power consumption device, it is recommended to enable the power saving mode via +UPSV AT command. Depending on the configuration of the serial line used, different +UPSV modes can be selected (see the system integration manual [4] [5] and the AT commands manual [1]).

To benefit from the enhancement of the LPWA standards, the power saving mode (PSM) can be enabled too. In normal service in LTE Cat M1 and NB-IoT, during inactive phases the PSM feature forces the module to enter a low power mode state, where the module is totally deactivated. The state is exited either if the host application needs to trigger data or AT commands, or when the device shall perform the periodic registration to the LTE network, which in PSM is done less frequently than in normal, non-PSM operational mode (for example, after a few hours). Overall, this behavior is more convenient with respect to usage of on-demand radio switch off/on via AT+CFUN=0/1 but has the disadvantage of long-lasting non-reachability periods while the device is deactivated. Similarly, host applications using mobile-terminated user data (for example, SMS) can rely on eDRX (extended DRX) to keep the power consumption at an optimal level while retaining reachability.

LEXI-R422 / SARA-R42 series modules assure enhanced coverage thanks to the support of CE (Coverage Enhancement) modes A and B; this benefit is balanced by longer transmission duration due to the several repetitions, which the host application can mitigate by using a reduced transmission duty cycle for optimal tradeoff.

Related documentation

[1]   u-blox SARA-R4 / LEXI-R42 series AT commands manual, UBX-17003787
[2]   u-blox SARA-R4 series data sheet, UBX-16024152
[3]   u-blox LEXI-R42 series data sheet, UBX-22020834
[4]   u-blox SARA-R4 series system integration manual, UBX-16029218
[5]   u-blox LEXI-R42 series system integration manual, UBX-23007449
[6]   u-blox SARA-R4 / LEXI-R42 FW update application note, UBX-17049154
[7]   u-blox SARA-R4 production and validation test app note, contact technical support
[8]   u-blox LEXI-R42 production and validation test app note, contact technical support
[9]   u-blox SARA-R4 / SARA-R5 / LEXI-R42 Internet applications development guide application note, UBX-20032566
[10]   u-blox Positioning implementation application note, UBXDOC-686885345-1826
[11]   u-blox Mux implementation in cellular modules application note, UBX-13001887
[12]   u-blox LwM2M objects and commands application note, UBX-18068860
[13]   u-blox SARA-R5 / SARA-R422 / LEXI-R42 AWS IoT Core application note, UBX-20044809
[14]   u-blox EVK-R4 user guide, UBX-16029216
[15]   u-blox EVK-LEXI-R422 user guide, UBXDOC-686885345-1758
[16]   3GPP TS 24.008 - Mobile radio interface layer 3 specification
[17]   3GPP TS 27.010 V3.4.0 - Terminal Equipment to User Equipment (TE-UE) multiplexer protocol (Release 1999)
[18]   GSMA TS.34 IoT Device Connection Efficiency Guidelines

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Revision history

Revision	Date	Name	Comments
R01	27-Apr-2021	fdil	Initial release
R02	09-Oct-2022	fdil	SARA-R42 "00B" IP release.
R03	17-Nov-2022	fdil	Added support for SARA-R42 "01B" product versions.
R04	27-Jul-2023	fdil	Inserted further indications for SARA-R42 series modules.
R05	06-Oct-2023	fdil	Added support for LEXI-R42 series modules.
R06	02-Sep-2024	fdil	Added support for SARA-R42 "01B-02" product versions.

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